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Men Who Fly Them**
By **KEN GILMORE**

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Illustration by John H. Johnson

THE TRUTH ABOUT The Amazing F-111 from the men who fly them

By C. P. GILMORE

It's not beautiful. Its black, drooping snoot reminds you of Charlie Brown's dog, Snoopy. Its stabilators—jet-pilot talk for what used to be called elevators—are misshapen barn doors. Its oversize landing gear makes it look like those children's stamped-metal airplanes with wheels too large for the body.

It's the F-111 fighter-bomber—perhaps the most controversial weapon since gunpowder. The Air Force says it's the best airplane in history. Sen. John L. McClellan, chairman of the Government Operations Committee, calls it a flop, a multibillion-dollar blunder.

To see for myself, I recently went to

Nellis Air Force Base, Nev. There, the first operational squadron of F-111s is undergoing intensive training. The Air Force isn't talking for the record, but it's an open secret that the squadron is headed for Vietnam soon—perhaps by the time you read this.

At Nellis, I watched the much-discussed General Dynamics bird in operation, ogled maintenance crews taking it apart and putting it back together, talked with the pilots who fly it.

I came away with two oddly contradictory opinions:

- First, the Air Force is right. It's the world's fastest and most versatile fighter-bomber. No plane anywhere combines such a package of abilities—short takeoff

Continued

For takeoff, pilot moves F-111's swing wings to full forward position to get maximum lift. Leading-edge "slats" help. So do trailing-edge flaps, increasing wing area by half. With wings swept back, the craft flies at $2\frac{1}{2}$ times the speed of sound, yet takes off and lands far shorter than any other fighter-bomber. This is Navy version.



Controversial swing-wing F-111

TWO TURBOFAN ENGINES

INFRARED
WARNING

F-111A (USAF)



will be the backbone of U.S. air power in the 1970s



F-111B (NAVY)



**PAINTINGS BY
BOB McCALL**

Tektite may serve as a model for underwater homes of the future

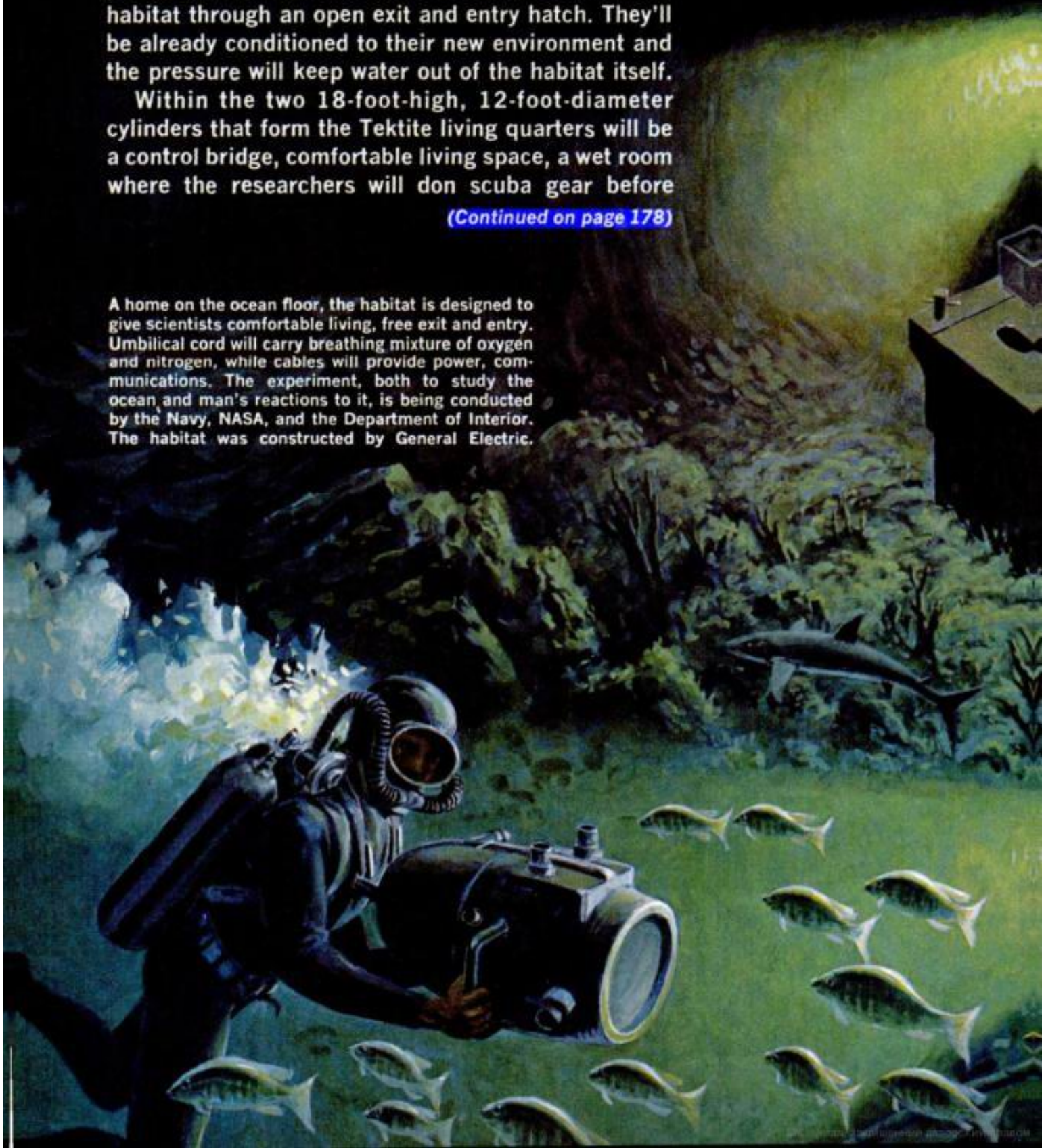
means that after 24 to 36 hours the body tissues of the crew will become saturated with the gases in the breathing mixture. The advantage: Living at ocean pressure, they'll be able freely to enter and leave the habitat through an open exit and entry hatch. They'll be already conditioned to their new environment and the pressure will keep water out of the habitat itself.

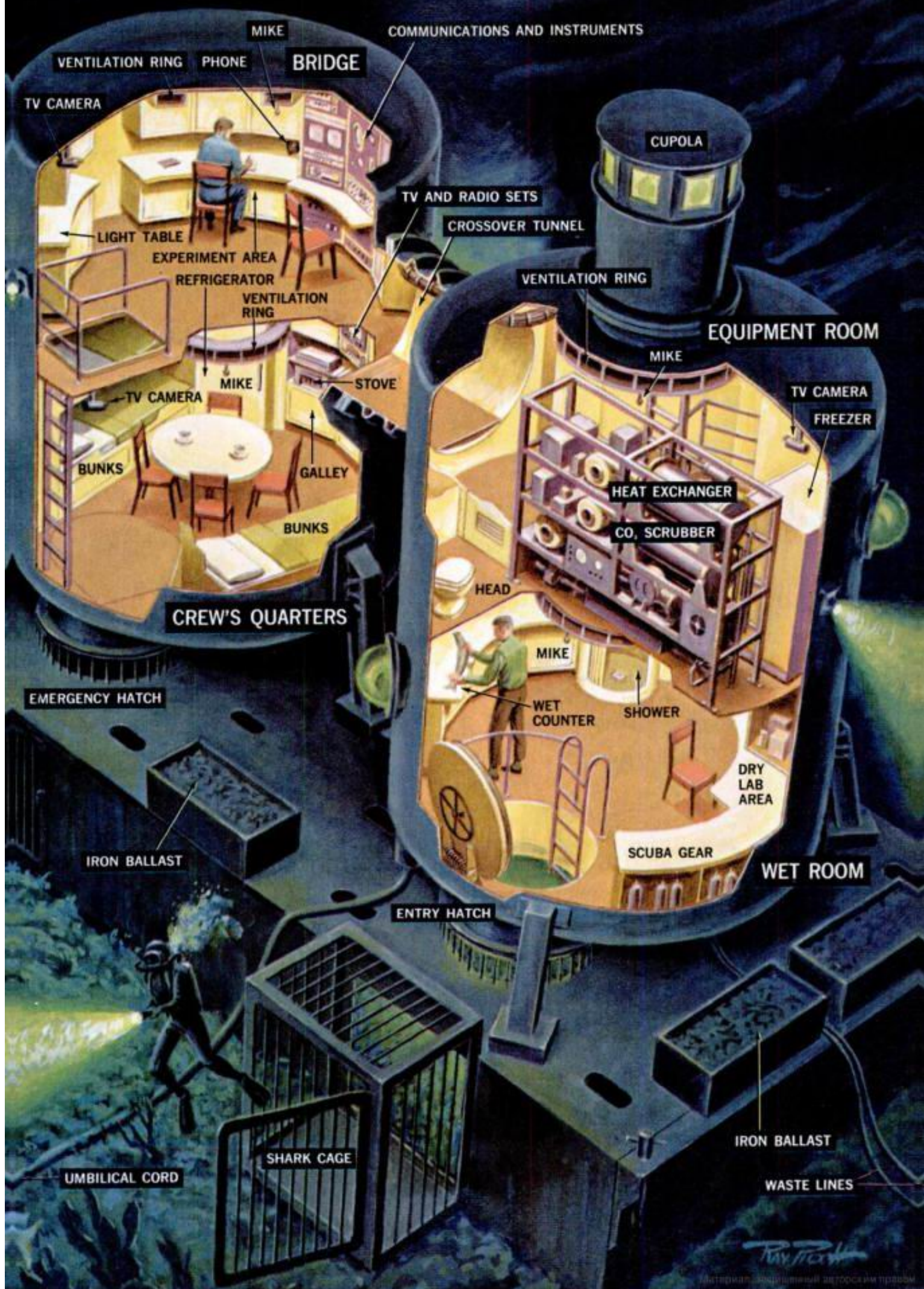
Within the two 18-foot-high, 12-foot-diameter cylinders that form the Tektite living quarters will be a control bridge, comfortable living space, a wet room where the researchers will don scuba gear before

ILLUSTRATION BY RAY PIOCH

(Continued on page 178)

A home on the ocean floor, the habitat is designed to give scientists comfortable living, free exit and entry. Umbilical cord will carry breathing mixture of oxygen and nitrogen, while cables will provide power, communications. The experiment, both to study the ocean and man's reactions to it, is being conducted by the Navy, NASA, and the Department of Interior. The habitat was constructed by General Electric.





**OPERATION TEKTITE—the amazing
story of how four scientists will
live and work for**

SIXTY DAYS ON THE OCEAN FLOOR

**Can we adapt to life in an alien environment? In this
unique experiment, researchers hope to learn more
about the ocean and men under stress**

By W. STEVENSON BACON

The first settlers on a vast new continent, the ocean floor, will be four scientists. In one of the most dramatic, longest experiments ever conducted they will live and work for two months in a specially designed habitat installed 50 feet below the ocean surface. And they'll carry on with their daily activities much as you and I do on land.

The name of this bold pioneering project is Tektite I. (Tektites are small, glass-like mineral fragments from outer space that are found both on land and in the ocean.) The name was inspired by the combination of ocean and space technology represented by the habitat.

The men in Tektite will live under compression. That is, the pressure of their atmosphere will equal the pressure of the ocean. This became possible with recent Navy research that resulted in the development of saturation diving techniques. "Saturation"

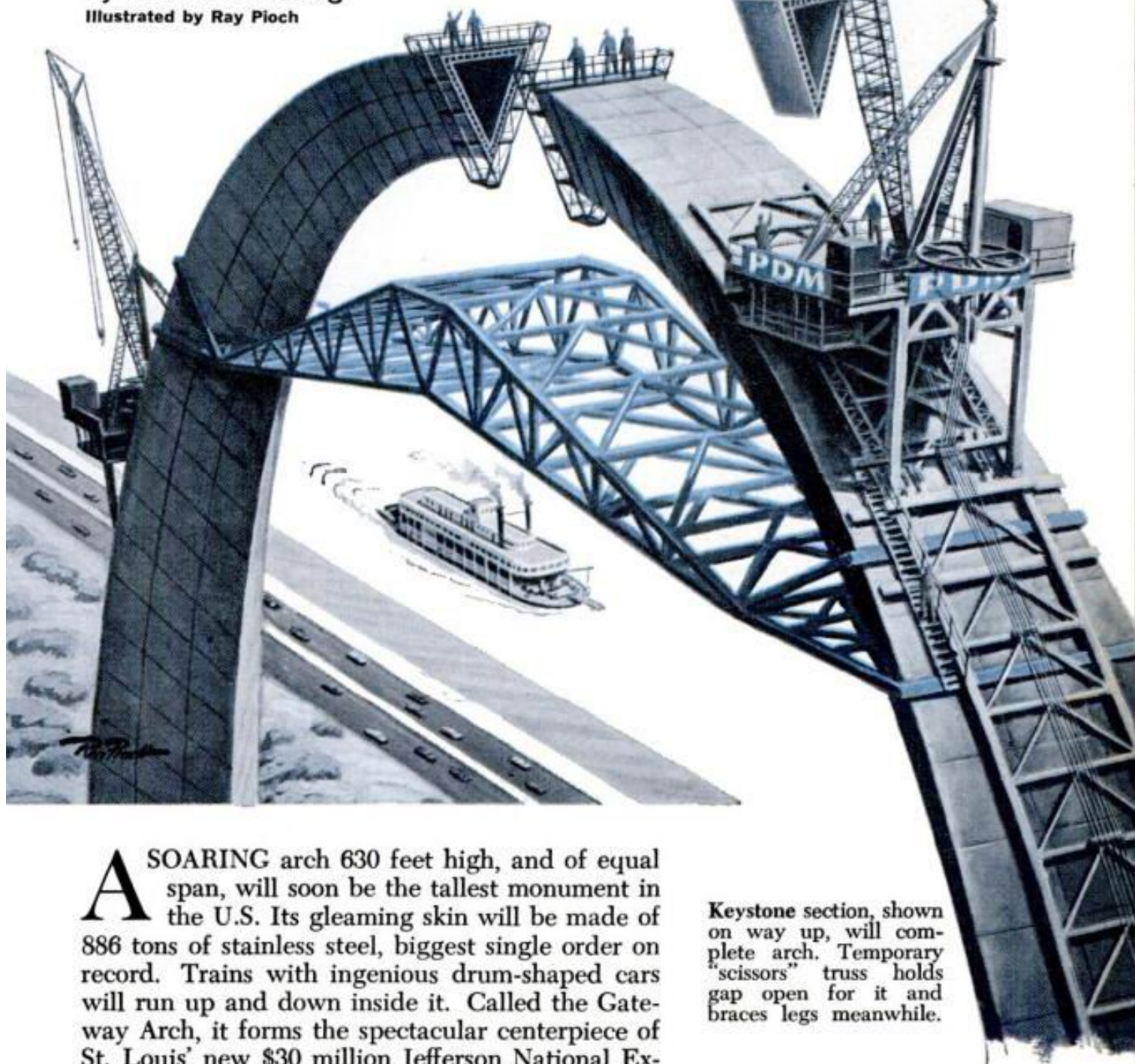
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**St. Louis'
two-legged tower:**

Tallest U.S. Monument

By Charles Remsberg

Illustrated by Ray Ploch



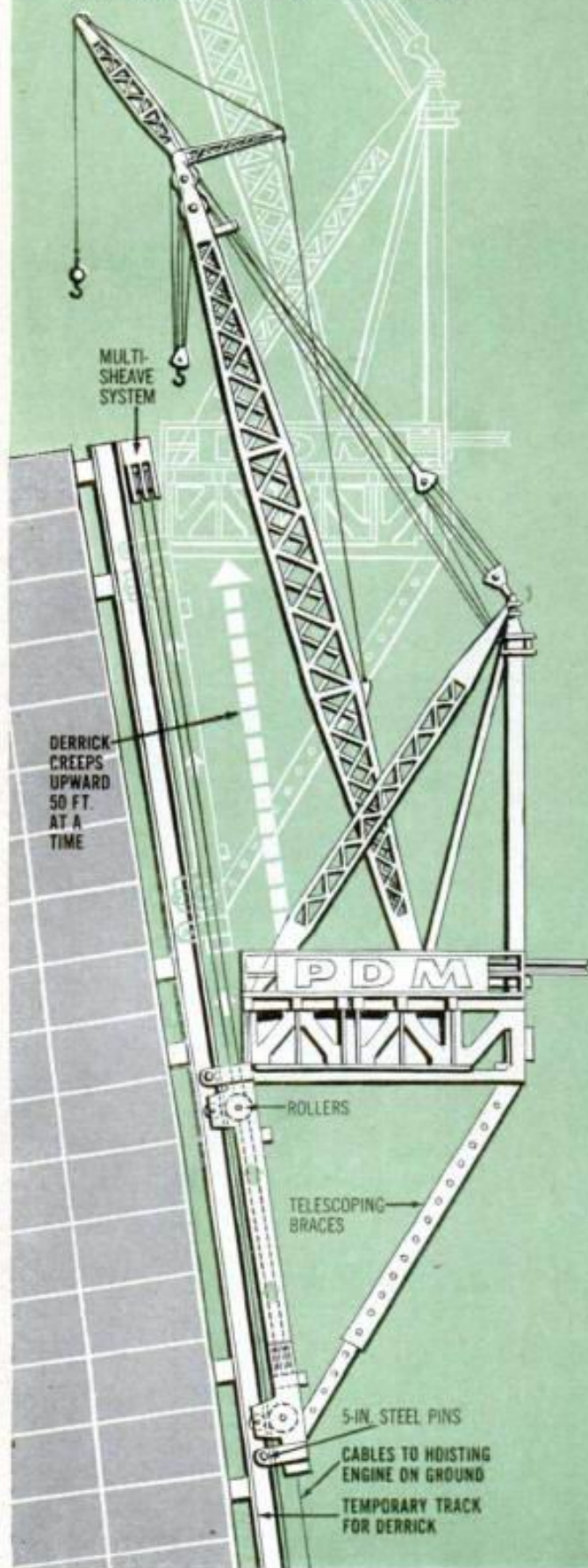
A SOARING arch 630 feet high, and of equal span, will soon be the tallest monument in the U.S. Its gleaming skin will be made of 886 tons of stainless steel, biggest single order on record. Trains with ingenious drum-shaped cars will run up and down inside it. Called the Gateway Arch, it forms the spectacular centerpiece of St. Louis' new \$30 million Jefferson National Ex-

Keystone section, shown on way up, will complete arch. Temporary "scissors" truss holds gap open for it and braces legs meanwhile.

CONTINUED

CREEPING DERRICK

To lift arch's sections into place, 100-ton derrick climbs each leg as it rises. Machinery on the ground powers derrick, and boosts it to next-higher level.



pansion Memorial Park. It symbolizes the city's role as the gateway to the West after the Louisiana Purchase of 1803.

Now under construction, the Gateway Arch will rise even higher than the 555-foot Washington Monument or the 302-foot Statue of Liberty when completed next year. Throughout its span the hollow structure will have the shape, in cross section, of an equilateral triangle, whose sides increase in exterior length from 17 feet at the top to 54 feet at each base.

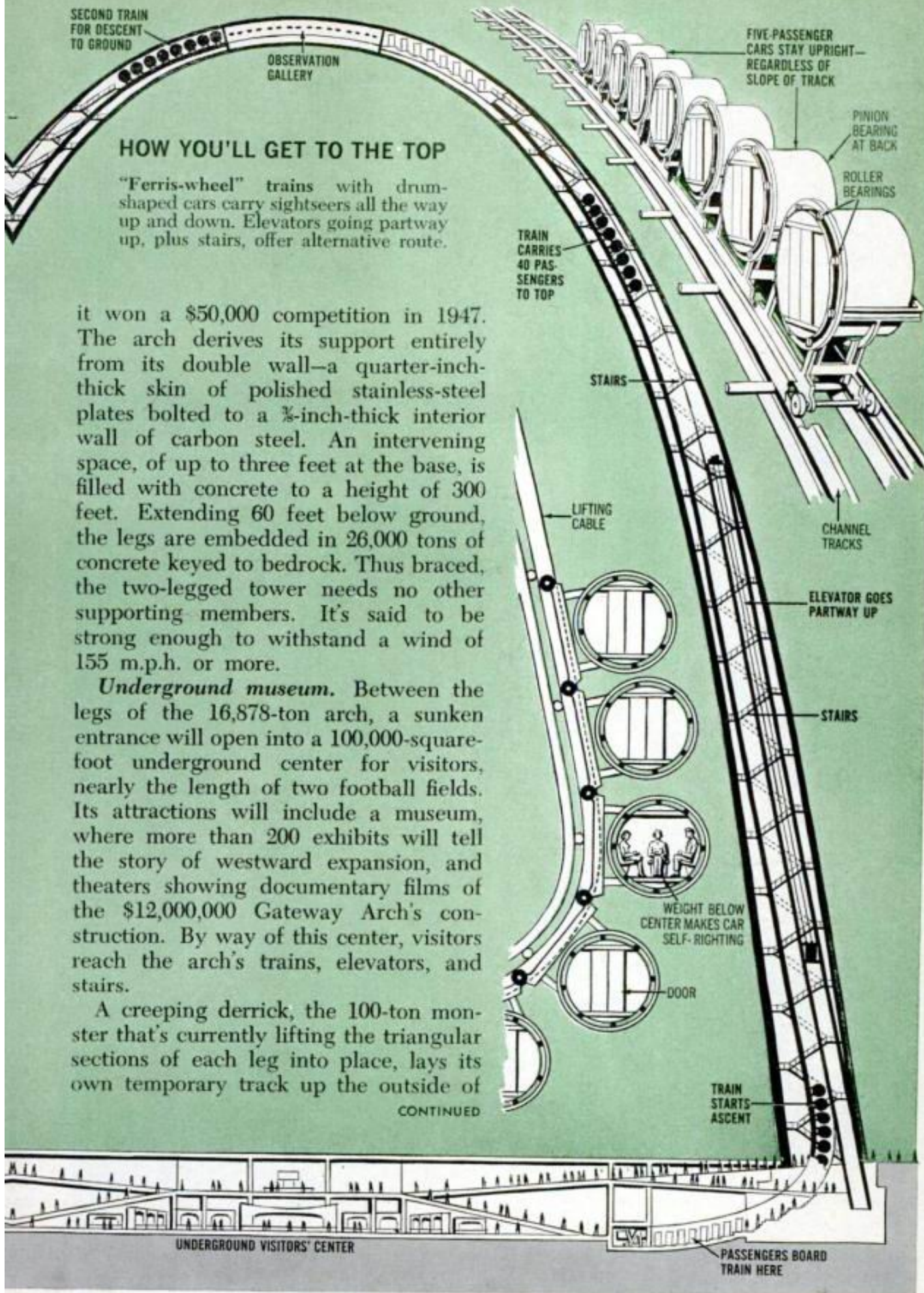
Room at the top. Visitors to the shining arch, which will be visible 30 miles away, will be able to look back over the same 30 miles: from a portholed observation gallery at its crown. To lift sightseers to this height, conventional elevators were ruled out by the arch's curving shape. So a brand-new form of vertical transportation is being provided.

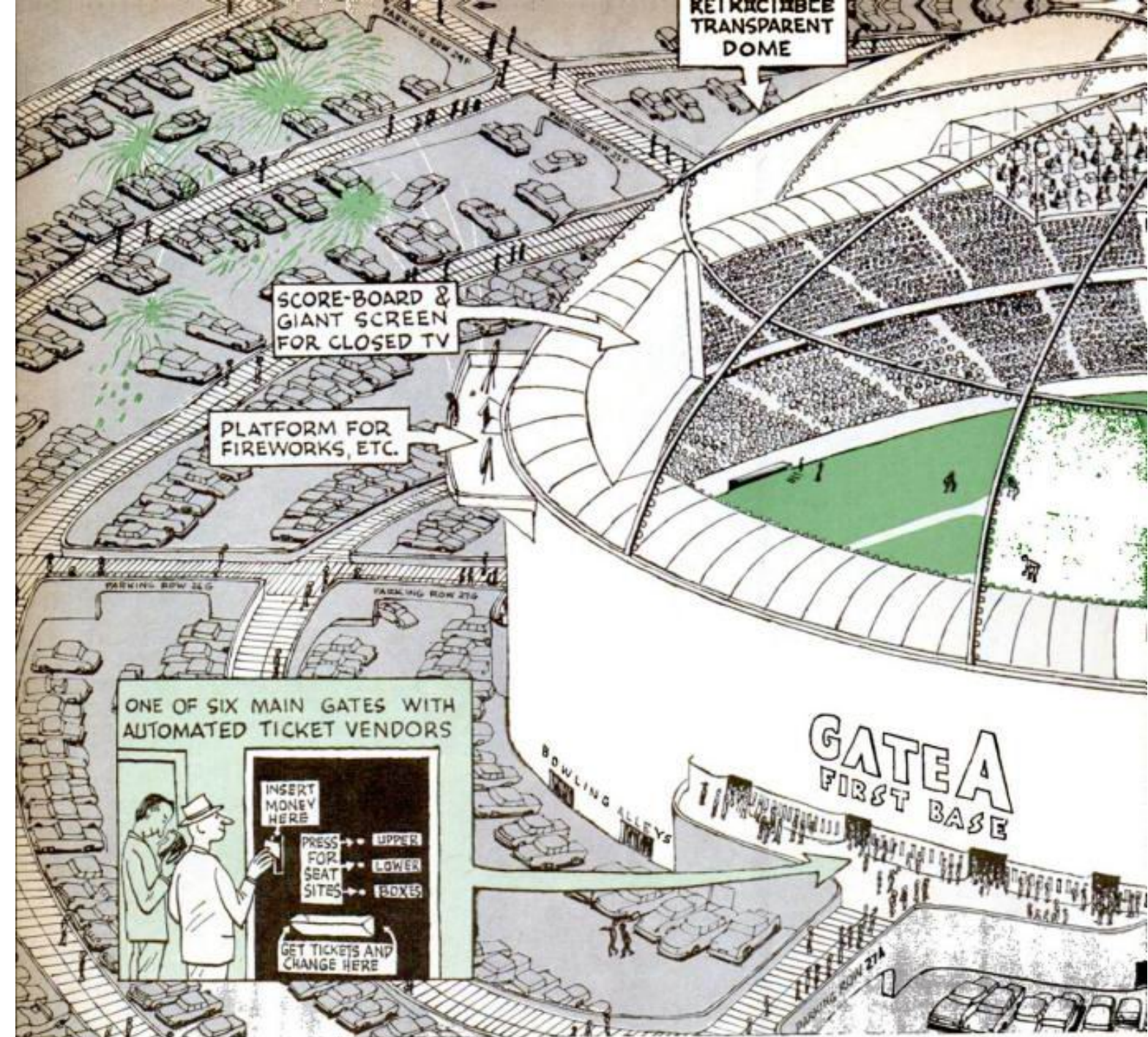
You'll ride aloft in a train consisting of eight five-passenger cars, propelled by a lifting cable and running along a track built into the structure. Each drumlike car hangs, free to rotate, in bearings at front and rear. Its below-center weight keeps it upright, like a seat on a Ferris wheel, during the 2½-minute ascent at just under four m.p.h.

Disembarking at the top of the arch, you'll pass through the observation gallery—and then ride down the other leg, in a "down" train just like the "up" one. (When traffic is light, each train may carry passengers both up and down.)

If you're too timorous to ride in the trains, you may ascend as far as the 370-foot level—more than halfway up—in an elevator especially designed to operate in a slanted shaft. You'll have to complete the ascent under your own power, via stairs, which extend all the way up and down each leg.

Creator of the Gateway Arch's design was the late Eero Saarinen, famous Finnish-born architect, whose plans for





By Bill Veeck

Former president of the Cleveland Indians, St. Louis Browns, and Chicago White Sox.

How I'd Build **The Perfect Ball Park**

BASEBALL has never been accused of being progressive. In the words of one ball-park operator, "If it wasn't done in 1901, it can't amount to much." You can see this kind of thinking in even the newest baseball stadiums. Most *might* have been considered modern

[Continued on page 184]

GLASS-ENCLOSED RESTAURANT



NIGHT LIGHTS
IN DOME BEAMS



MOTEL FOR
PLAYERS, ETC.

GIANT SCOREBOARD
AND TV SCREEN

PLATFORM FOR
FIREWORKS, ETC.

REMOVABLE
SOD

FOAM-
CUSHION
SEATS

MOVABLE SEAT
SECTIONS FOR
SMALLER EVENTS



AUTOMATIC
HOT-DOG AND
DRINK VENDORS

INTERIOR
ESCALATORS

TWO-WAY WALKWAYS & ESCALATORS



PARKING
AREAS

SHOPPING
CENTER

DEPARTMENT
STORE

Coming...Ferries to Space

Re-usable launch vehicles, looking more like airplanes than rockets, will boost manned and unmanned craft into orbit

Models illustrate first stage and smaller second stage of the recoverable vehicle for space launchings that the author sees ahead.



By Dr. Wernher von Braun

Director of NASA's George C. Marshall Space Flight Center, Huntsville, Ala.

IN THE near future, we may expect to see spacecraft put into orbit in a new way.

Many of them will be borne aloft by winged and manned vehicles that resemble airplanes more than rockets—and

that may even take off horizontally in airplane fashion, rather than vertically like rockets. The most important thing about these radical launch vehicles is that they will return safely to earth, to be used over and over again.

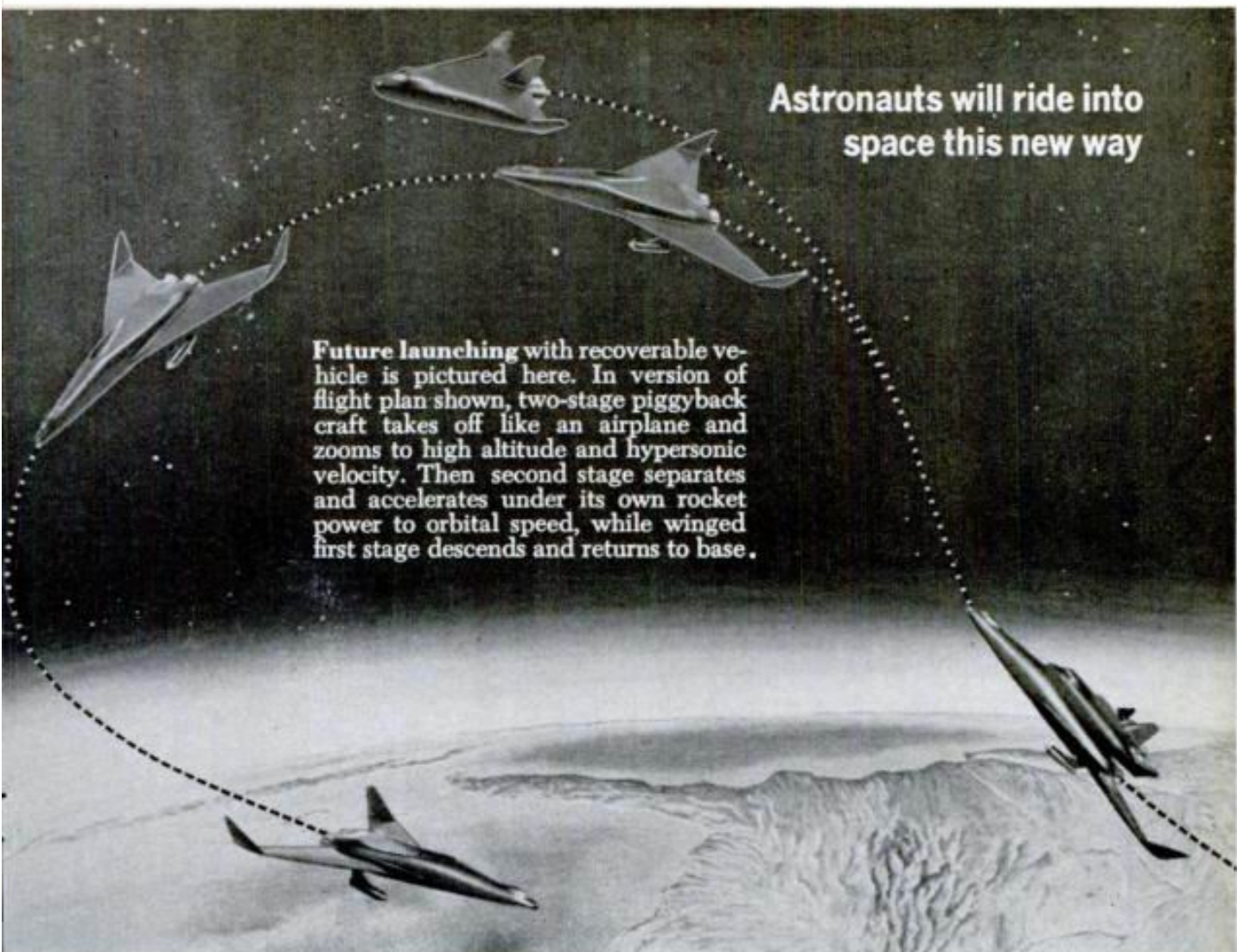
Space flight today is still awfully expensive. Among the biggest items of cost, of course, are the large launch rockets required to hurl manned and unmanned spacecraft into orbit or beyond.

Up to now, all launch rockets have been strictly one-shot vehicles. Whether or not a spacecraft reaches its orbit and performs as expected, the launch vehicle is invariably consumed in the process.

Even with our most advanced launch vehicles, it still costs about \$500 to send one pound of net payload into orbit. We must drastically reduce this cost if we are



Dr. von Braun, right, attends a briefing at NASA's Manned Spacecraft Center in Houston with its director, Dr. Robert R. Gilruth.



Astronauts will ride into space this new way

Future launching with recoverable vehicle is pictured here. In version of flight plan shown, two-stage piggyback craft takes off like an airplane and zooms to high altitude and hypersonic velocity. Then second stage separates and accelerates under its own rocket power to orbital speed, while winged first stage descends and returns to base.

to take full advantage of the tremendous potentials of space flight for scientific, commercial, and military purposes. Re-usable launch vehicles will provide a way.

Ferries to space. I think we can expect a re-usable launch vehicle to become available at some time between 1970 and 1975. We can expect such a vehicle to be capable of at least 50 to 100 flights to orbit. There is no reason why it could not make at least one flight weekly. Under these assumptions, we can expect the cost of orbital transportation to drop from the present \$500 a pound to \$50 a pound, or even less.

In my judgment, for reasons that I shall come to presently, the needs of a suitable design for the first generation of a re-usable launch vehicle point toward a manned craft that will be capable of carrying something like a dozen passengers, plus about five tons of cargo, into a low earth orbit.

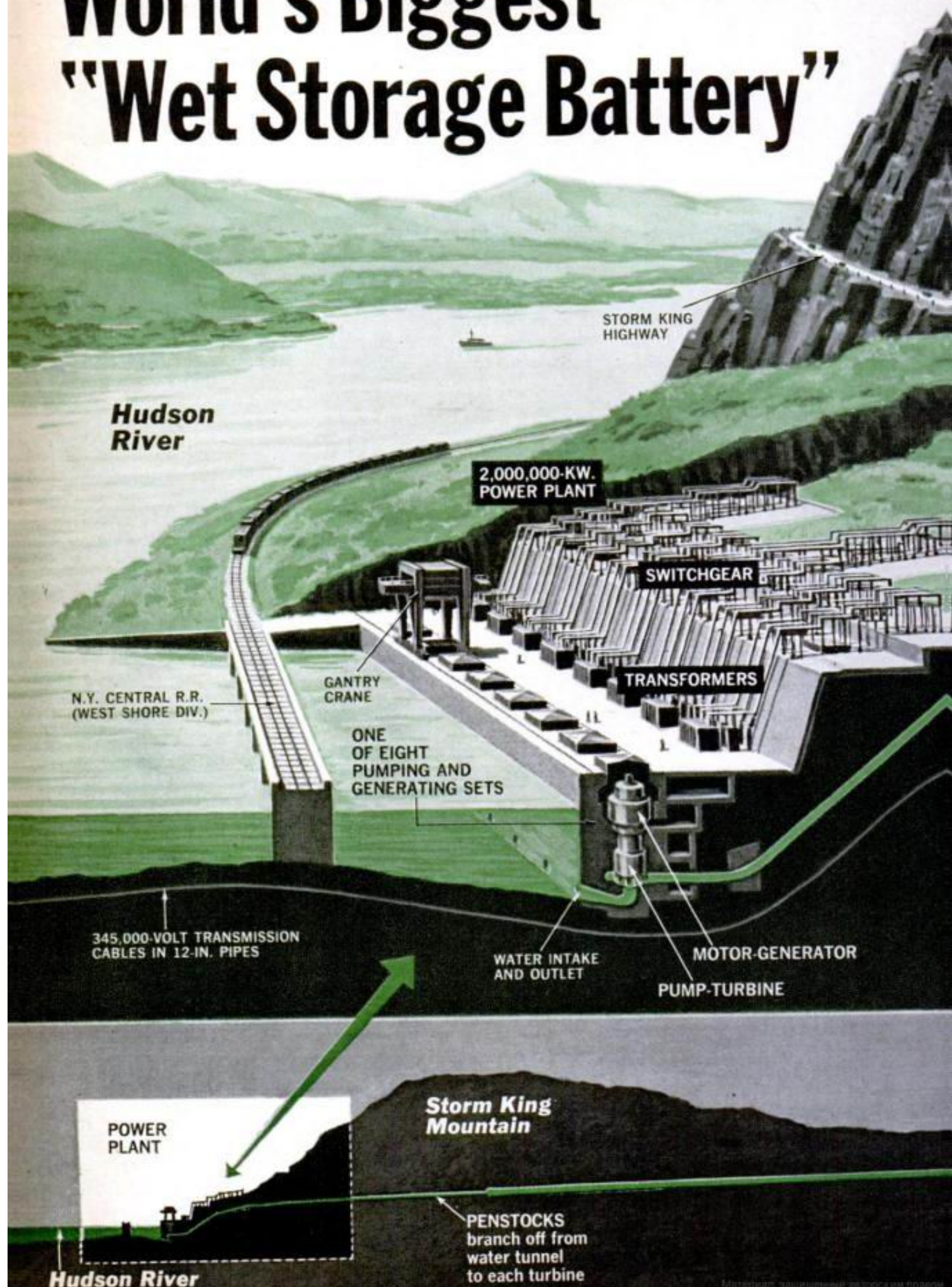
What will it look like? Envision an aircraft the size of one of our big jet airliners. This is the first stage of the re-usable launch vehicle. Nestled on its back is the second stage—a smaller aircraft shaped like the space glider of the now defunct Dyna-Soar project, or one of the “lifting-body” configurations under current study. Both first and second stages are manned—the first stage with a flight crew, the second stage with a flight crew plus passengers, if any.

The first stage may be powered either with liquid-rocket engines or with supersonic turbojet engines. If rocket engines are used, it may take off vertically like one of our present-day space boosters—or it may be launched horizontally from a catapult. In the case of air-breathing engines, a catapult-type horizontal launch is mandatory.

A rocket-powered first stage would ac-

[Continued on page 206]

World's Biggest "Wet Storage Battery"



**Storm
King
Mountain**

Up-and-down waterfall to generate two million kilowatts of electric power

THROUGH a tunnel bigger than a vehicular tube, at Cornwall, N. Y., electric pumps will lift water 1,160 feet from the Hudson River to a mountain-top reservoir. Then the water will cascade back down—and the pumps will turn into turbines, to yield two million kilowatts of power. The \$162-million “pumped storage” project, when completed in the late sixties by the Consolidated Edison Company, will be the largest in the world.

Why pump water uphill and let it run down again? You get back only two-thirds of the power you put in—but you get it when you want it.

Electricity, in city-size amounts, can't be stored. It has to come fresh from generators. And demand for juice fluctuates around the clock. Build enough conventional power plants for a city's peak needs, and some will stand idle in “off-peak” hours. The answer is pumped storage—made feasible by the introduction of reversible pump-turbines in the mid-fifties, and already applied in installations ranging up to one of 900,000 kilowatts in Luxembourg.

Con Ed's plant on the Hudson will act like a gigantic storage battery. All night, spare current from New York's steam power plants will flow to Cornwall and pump water aloft. In the morning, releasing the water will drive turbines and send current back. Pumping over weekends will make up for any excess of outflow over inflow on weekdays.

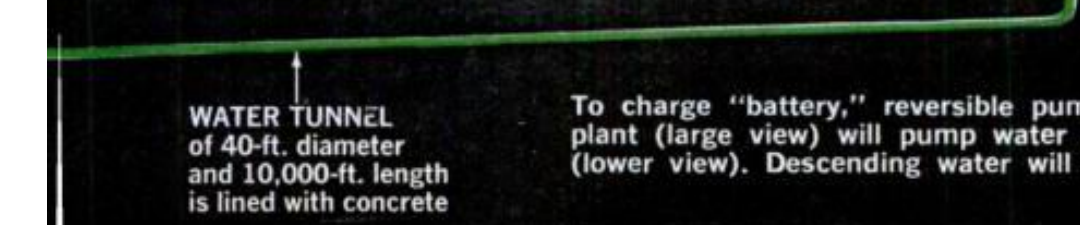
Power will flow between Cornwall and New York in 345,000-volt transmission lines, and will cross the Hudson in the first extra-high-voltage submarine cables to span a major river.—*Harry Walton.*



PENSTOCK
(TO NEAREST
TURBINE)



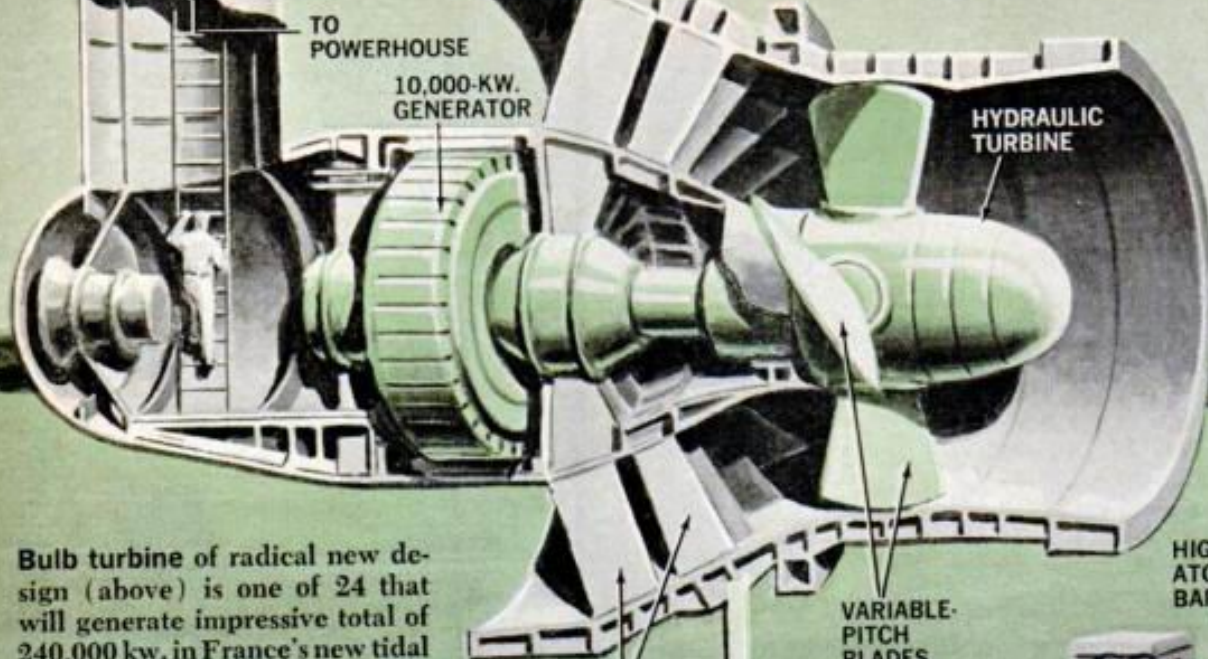
RESERVOIR
1,160 ft. above river
covers 240 acres



WATER TUNNEL
of 40-ft. diameter
and 10,000-ft. length
is lined with concrete

To charge “battery,” reversible pump-turbines of Cornwall plant (large view) will pump water from river to reservoir (lower view). Descending water will then generate current.

THE BULB TURBINE



Bulb turbine of radical new design (above) is one of 24 that will generate impressive total of 240,000 kw. in France's new tidal powerhouse (below) at mouth of Rance River on English Channel. Turbine and generator coupled to it occupy a 50-foot-long bulb suspended in water tunnel.

SUPPORTING AND WATER-GUIDING VANES

River side

HIGHWAY ATOP BARRIER

GALLERY

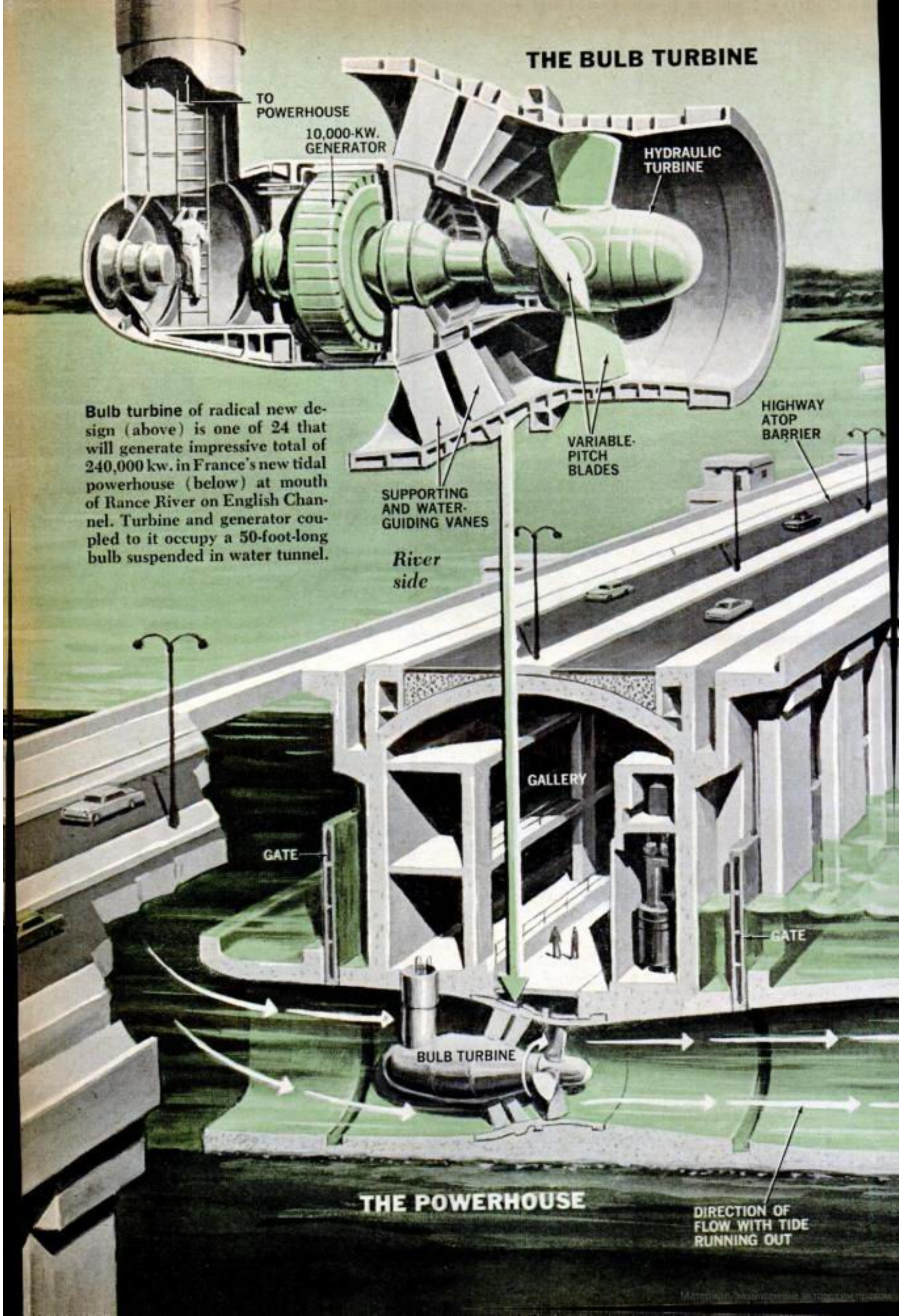
GATE

GATE

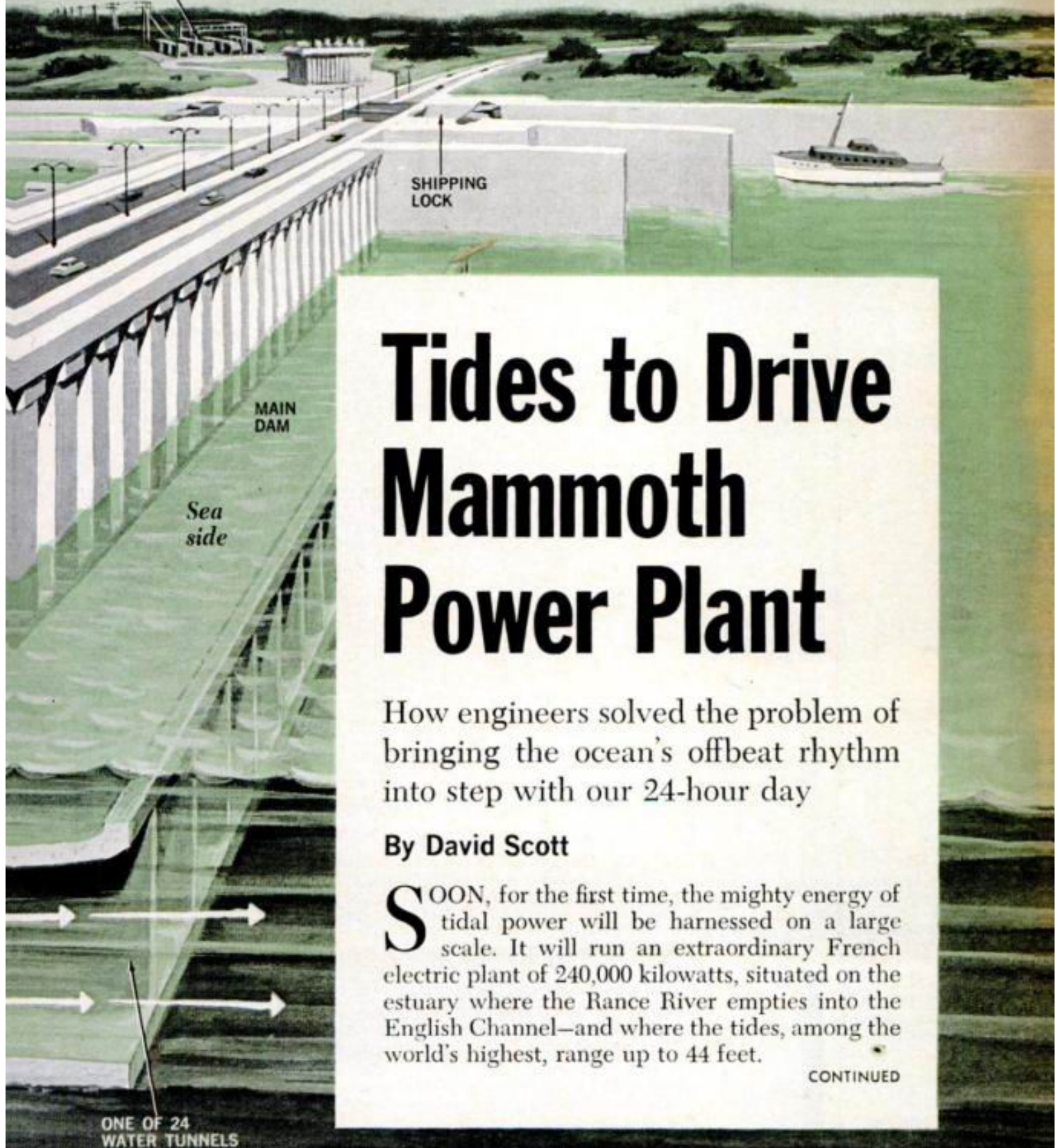
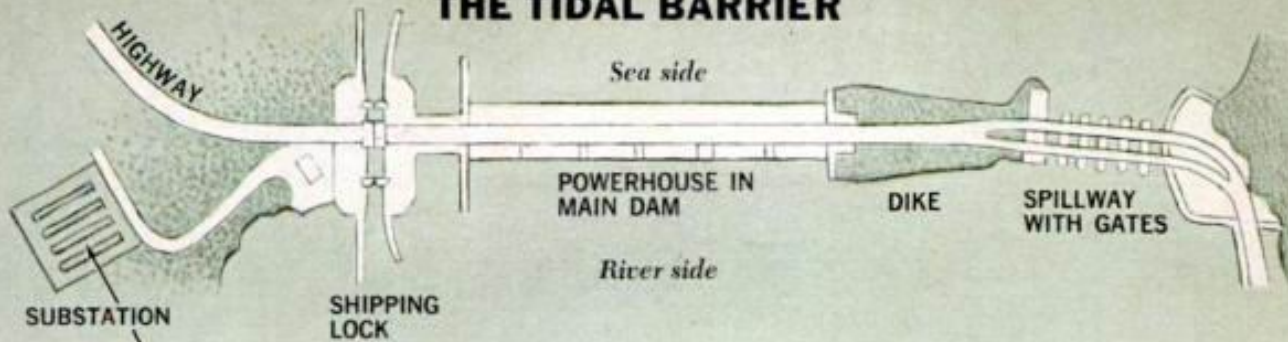
BULB TURBINE

THE POWERHOUSE

DIRECTION OF FLOW WITH TIDE RUNNING OUT



THE TIDAL BARRIER



Tides to Drive Mammoth Power Plant

How engineers solved the problem of bringing the ocean's offbeat rhythm into step with our 24-hour day

By David Scott

SOON, for the first time, the mighty energy of tidal power will be harnessed on a large scale. It will run an extraordinary French electric plant of 240,000 kilowatts, situated on the estuary where the Rance River empties into the English Channel—and where the tides, among the world's highest, range up to 44 feet.

CONTINUED



GOING UP: Takeoff varies from exact vertical by only few feet as shown in one of the tests at

Takes off straight up, lands straight



Hovering motionless like helicopter, XV-5A is suspended in air by fans in wings. Grilles on the underside are louvers, and V-shaped objects on top of wings are butterfly-hinged doors, closed for normal flight.

NOSE FAN AND
INLET LOUVERS

EJECTION
SEATS

TURBOJET
AIR INLET

TWO TURBOJET
ENGINES

WING LIFT FAN



Lou Everett, Ryan test pilot, holds conventional control stick. All cockpit controls and instruments are of kind used by fixed-wing and helicopter pilots. Transition from vertical and forward flight is made without shifting foot or hand position.

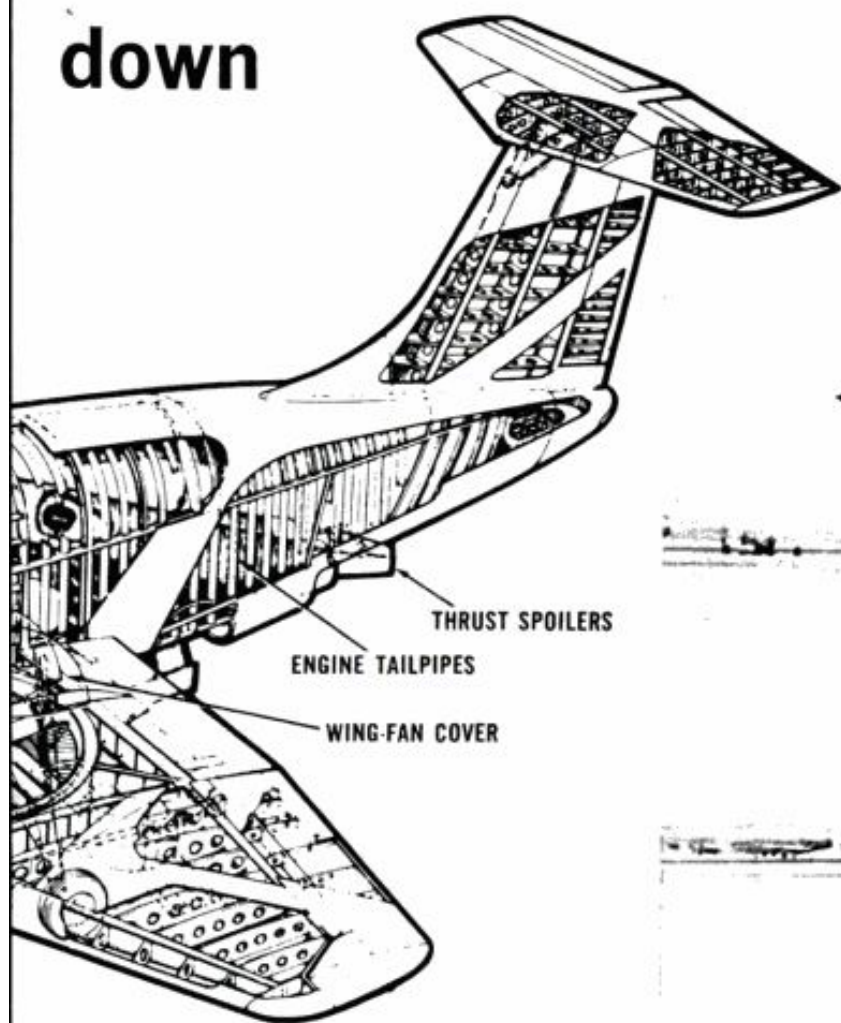
The Army's new XV-5A takes off vertically or from a short landing field and flies at near the speed of sound at tree-top level or an altitude of 35,000 feet. It can hover like a helicopter and land on a dime.

Powered by two GE J85 turbojets and built by Ryan, the lift-fan plane gets lift from thrust diverted to wing fans also developed by GE. A third turbofan in the nose provides lift and pitch control. In transition to horizontal flight, diverter valves redirect all the jet stream through the tailpipes. Vanes under the



Edwards Air Force Base, Calif. Note as reference points stationary cars and planes in background.

down



COMING DOWN: Plane, seen over truck in top photo, moves just beyond group (bottom photo) short distance away.



wing fans are first angled, then closed, and butterfly lids on top are shut to provide an airfoil surface. Transition to normal flight can be made at level altitude or in climb.

Basic thrust of the two engines is 5,316 pounds, nearly tripled in lift power by accelerating the exhaust when diverting to the wing fans.

The XV-5A is rated at Mach 0.72 at sea level (548 m.p.h.), Mach 0.77 at 25,000 feet, and can maintain an average of Mach 0.7 at 35,000 feet for a distance of up to 1,225 miles.

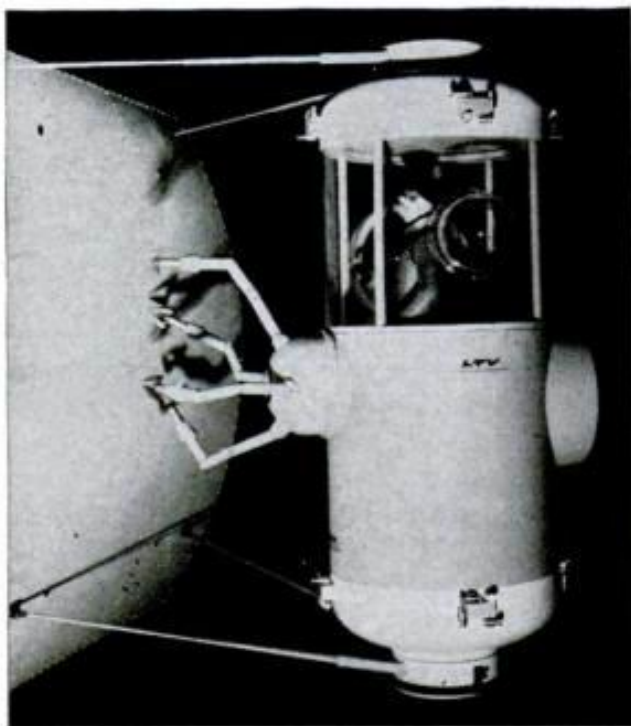
Coming—

A 'Mr. Fix-It' Space Car

When multimillion-dollar satellites conk out, a repair-making spacecraft with deft mechanical arms could put them back in working order—and here's a preview of what it may be like

By DR. WERNHER VON BRAUN

Director of NASA's George C. Marshall Space Flight Center, Huntsville, Ala.



Insect-like spacecraft with multiple fangs—manipulators and tools extending from their roundish bodies—may become the “Here-Comes-Help” wrecker cars of the Space Age.

Some of NASA's highly complex unmanned research satellites such as OAO-2, the Orbital Astronomical Observatory,

Space-repair car may look like one-man version at right. With manual controls, operator wields “hands” to grasp satellite and handle detached parts, and drill and other tools.

One-man “space taxi” is another concept of a repair craft. Model shows it anchored to satellite and going to work with remote-controlled “hands.”

have been eminently successful. A few, such as its predecessor, OAO-1, became bitter disappointments when a single component's failure turned a sophisticated multimillion-dollar array of instruments into useless orbiting junk.

Our astronauts' often-demonstrated ability to remedy troubles with ailing equipment has led to studies of how they could bring disabled satellites back to life. While the problem is not simple, there are promising possibilities.

A garage mechanic's ability to fix your car depends upon the attention the car's designer has paid to making critical parts accessible and easy to change and suitable tools available. As our unmanned satellites were never meant to be fixed



in orbit, no attention at all was paid to these things in their design. But this could be done in the future, now that we know we could send a repairman.

Being able to rendezvous an out-of-order satellite and approach it by "space-walking" is not enough. The sick satellite may be tumbling and its whirling, protruding parts may imperil an approaching EVA (extravehicular-activity) man. Concepts to stop the tumbling motion include a magnetic grappling device brought into position by a fearless space walker. This done, repair can begin.

But, prior to the therapy, there must be a correct diagnosis of the trouble—and only rarely will our repairman know his patient's ailment in advance.

Finding the trouble. Advanced spacecraft, manned or unmanned, are usually checked out (and monitored during countdown) through an external multi-pronged electric connector—which is disengaged at takeoff or shortly before. For his diagnosis, a space repairman must bring along a tape-controlled electrical-checkout device, plug it into that same spacecraft connector, and run a fault-isolation test.

Suppose he finds a certain valve of the satellite's attitude-control system must be replaced. The valve is part of a high-pressure system; removing it calls for disconnecting an electrical control cable and opening two B-nuts. For an EVA

Continued

They'll Commute by Elevator in 100-Story Tower

DRAWINGS BY RAY PLOCH

Something new in skyscrapers is rising in Chicago — a black-and-bronze tower 1,105 feet tall, second in height only to New York's Empire State Building, and the world's largest to put homes and offices under one roof.

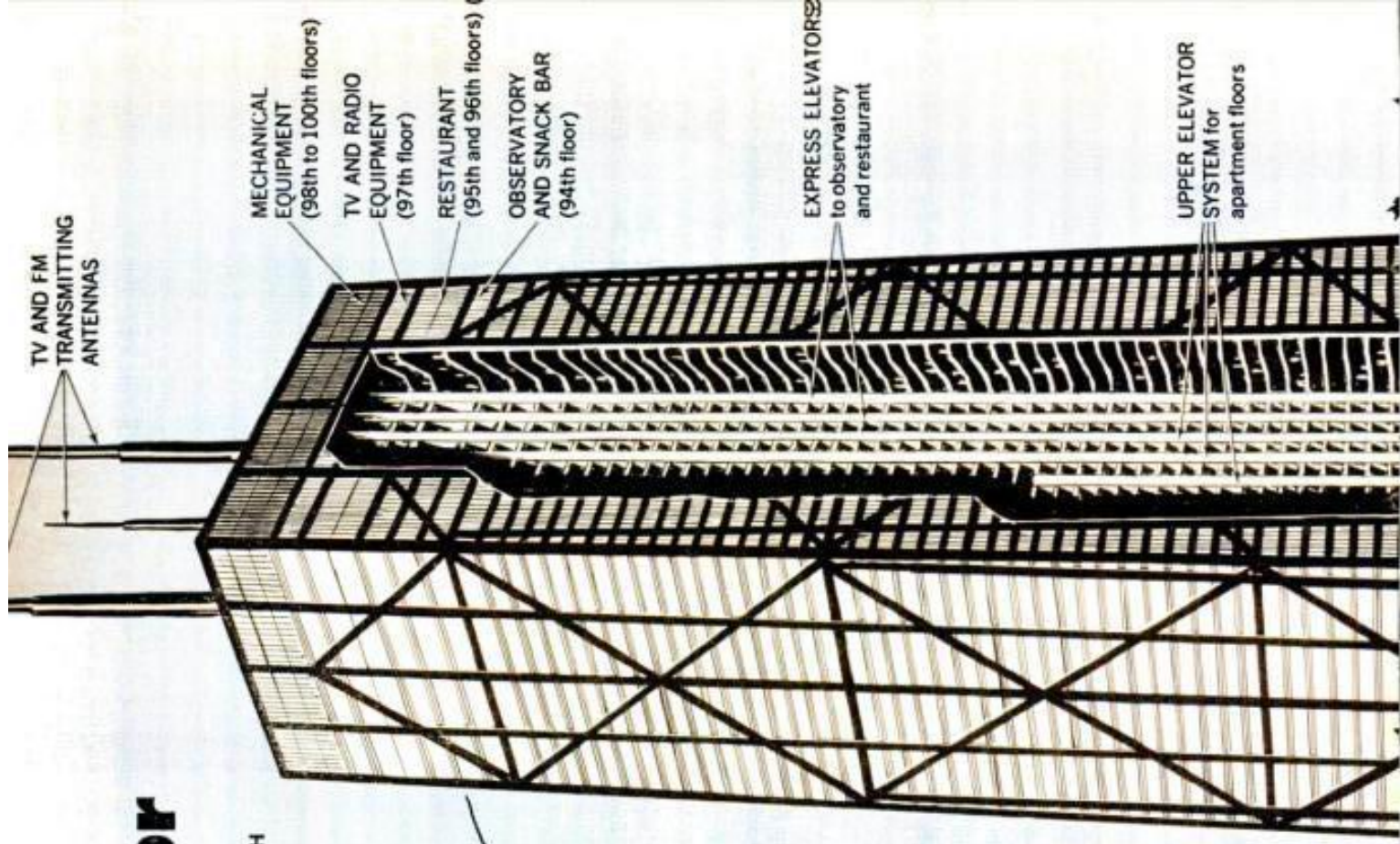
The 100-story John Hancock Center will offer 1,600 dwellers in its 48 floors of apartments the novel possibility of commuting by elevator — no trains to catch, no inclement weather or traffic to brave — to 29 floors of offices below. Restaurants, stores, and other facilities will serve a resident's needs so completely that, if he chose, he'd never need to leave the all-air-conditioned building.

Engineering design, besides arrangement, will divide the tower into its two worlds of living and working — at a boundary drawn by a two-level "Sky Plaza" occupying the 44th and 45th floors. Here, travelers between apartments and offices change elevators, of which separate systems will serve the floors above and below — an innovation that leaves more usable room by minimizing the space preempted by elevator shafts.

Structurally the tower will be the tallest to date to pioneer the ultramodern style of wearing its skeleton on its outside. A bridge-like X-braced exterior frame of structural steel will resist wind forces and, together with the central core, will support the building's weight, freeing the interior of obstructing pillars. The tower will be clad in black aluminum, accented by windows with bronze-colored aluminum frames and bronze-tinted glare-reducing glass — the world's largest aluminum-and-glass curtain wall. —Alden P. Armagnac.

APARTMENTS

Living accommodations on 46th to 93rd floors (48 stories) for the 1,600 residents consist of about 700 electrically heated and cooled apartments, from "efficiencies" to four-bedroom luxury layouts. Dwellers have separate ground-level entrance, high-speed



TV AND FM
TRANSMITTING
ANTENNAS

MECHANICAL
EQUIPMENT
(98th to 100th floors)

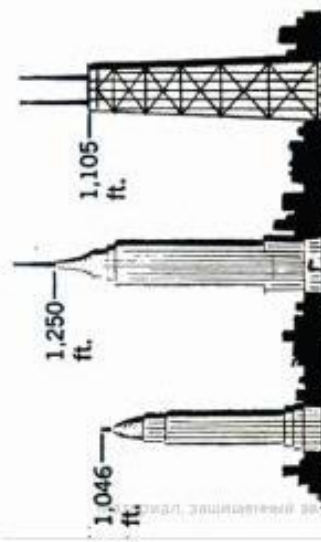
TV AND RADIO
EQUIPMENT
(97th floor)

RESTAURANT
(95th and 96th floors)

OBSERVATORY
AND SNACK BAR
(94th floor)

EXPRESS ELEVATORS
to observatory
and restaurant

UPPER ELEVATOR
SYSTEM for
apartment floors



WORLD'S TALLEST BUILDINGS COMPARED
CHRYSLER BUILDING
EMPIRE STATE BUILDING
JOHN HANCOCK CENTER

SKY PLAZA

Two-level arcade on 44th and 45th floors, the dividing line between homes and offices, is the terminal for elevators from ground-level entrance for residents—and they change here for other elevators to their living floors above. Located at the Sky Plaza are specialty stores and shops and a year-round swimming pool.

OFFICES

Business offices on 13th to 41st floors (29 stories) provide about a million square feet of column-free space and are expected to accommodate a total of about 7,500 office workers. Twenty-one high-speed passenger elevators and two service elevators serve the office floors of the building.

PARKING

Garage facilities on 6th to 12th floors (seven stories) provide heated parking space for 1,200 cars in new skyscraper. From ground level, a broad spiral ramp leads to the first parking floor at the sixth story. Cars are parked by attendants who pick them up and deliver them at street level, as at left.



X-BRACED STEEL FRAME, TOGETHER WITH CENTRAL CORE, SUPPORTS BUILDING

ALUMINUM-AND-GLASS WALL

LOWER ELEVATOR SYSTEM for office floors and to Sky Plaza

SPIRAL RAMP TO PARKING FLOORS

ENTRANCE LOBBIES, STORES AND SHOPS (1st to 5th floors)

MECHANICAL EQUIPMENT (42nd and 43rd floors)

Arena Rises Atop Buried

A great engineering project moves New York's famed Penn Station underground—and erects new Madison Square Garden above it

A cable-suspended roof 425 feet in diameter, largest of its kind in the U.S., will dispense with supporting pillars and give spectators an unobstructed view from every seat of New York's new Madison Square Garden. Express esca-

tors four feet wide will empty the arena of a capacity crowd in 22 minutes. Those are outstanding features of the \$44 million sports center, shown in the cutaway view below, now rising on the Pennsylvania Station's 8½-acre site.

**NEW 29-STORY
OFFICE BUILDING
on Seventh Ave.
side of site**

**GLASS-ENCLOSED
PEDESTRIAN MALL
CONNECTS OFFICE
BUILDING AND
SPORTS ARENA**

**ESCALATOR
TOWER**

**425-FT.-DIAMETER
CLEAR-SPAN ROOF**

ROOF IS
SUSPENDED BY
48 RADIAL
STEEL CABLES OF
3½-IN. DIAMETER

**EXTERIOR OF BROWN
PRECAST CONCRETE PANELS**

33rd St.

**ONE OF SIX SIDE LEVEL ENTRANCES
TO NEW UNDERGROUND PENNSYLVANIA STATION**

L. I. R. R. CONCOURSE

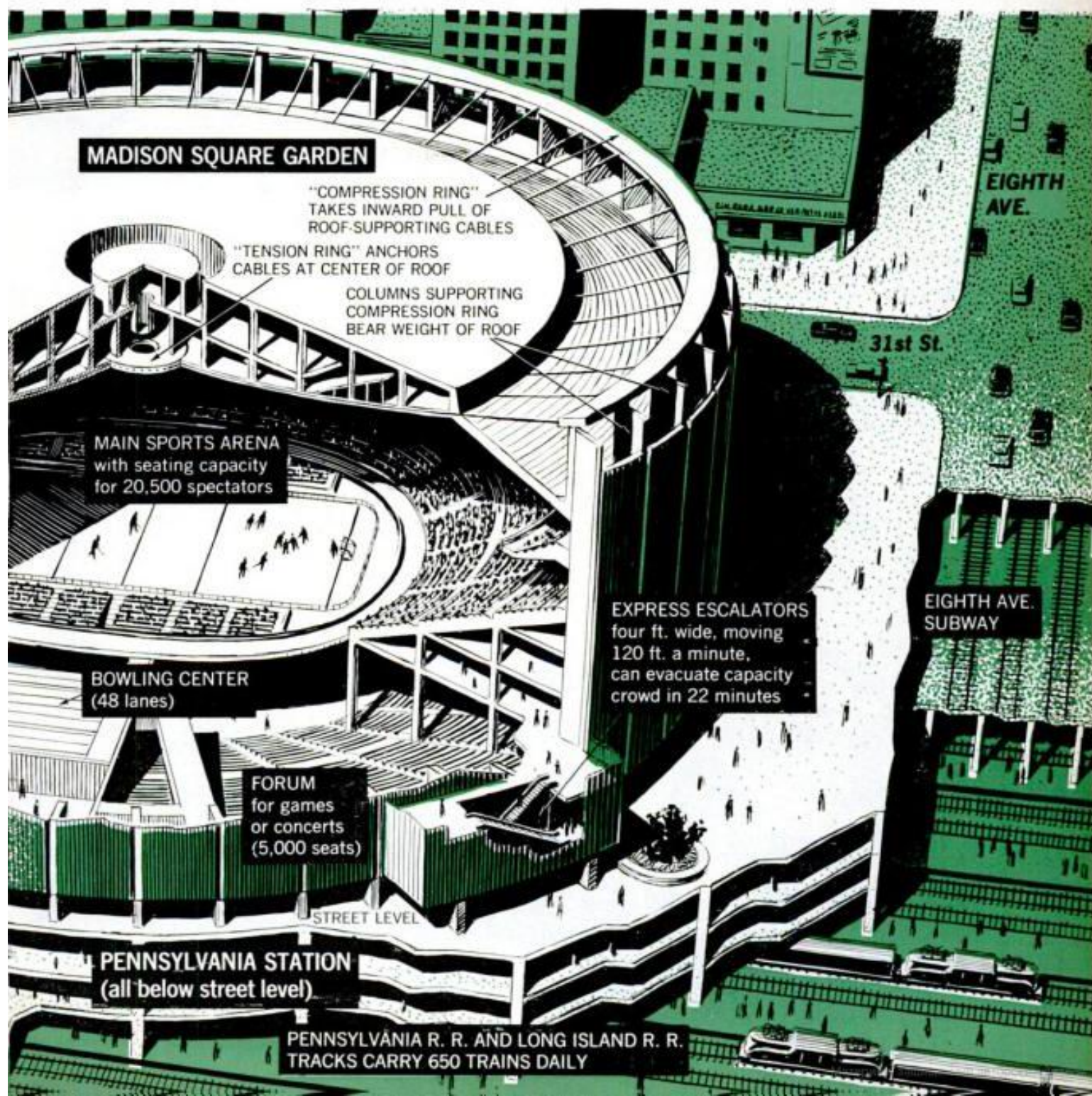
Rail Terminal

ILLUSTRATION BY RAY PIOCH

Meanwhile the earth is swallowing up the rail terminal. Being razed to the ground is a famous New York landmark, the Pennsylvania Station's Roman-columned marble building. Six street-level entrances will admit commuters and intercity travelers to a new underground station, enlarged and air-conditioned—its capacity actually increased by the \$10 million transformation. Thus P.R.R. and L.I.R.R. trains will run as us-

ual, while the Pennsylvania Railroad receives rent from the Garden for above-ground use of the handy-to-transit site.

Due for completion in the fall of 1967, the new drum-shaped Garden will provide a main arena seating 20,500 for major boxing matches, hockey and basketball games, bike racing, conventions, and circuses; and, among other facilities, a 5,000-seat "forum" suited to a tennis game or concert.



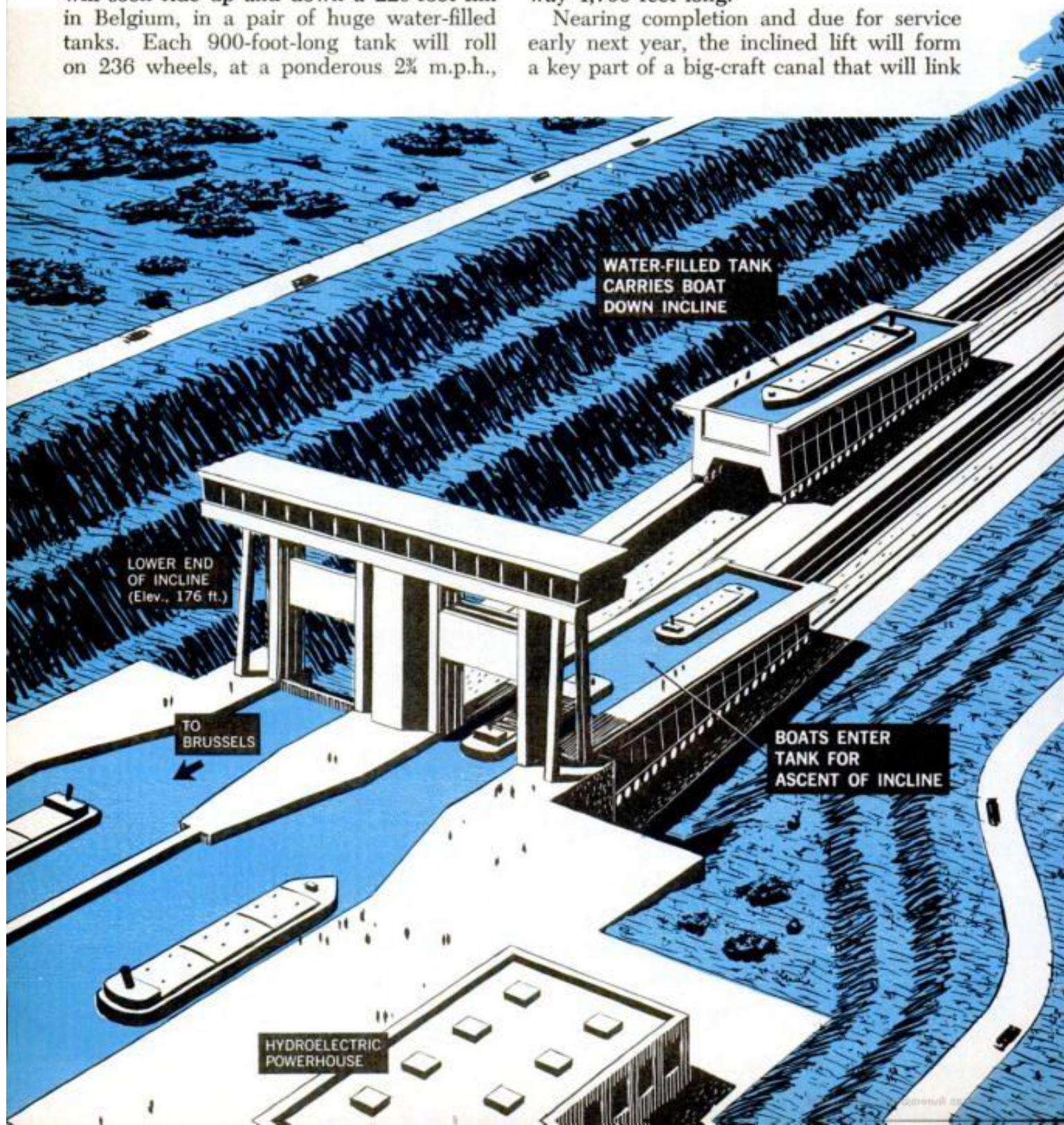
Ships Float Uphill and Down

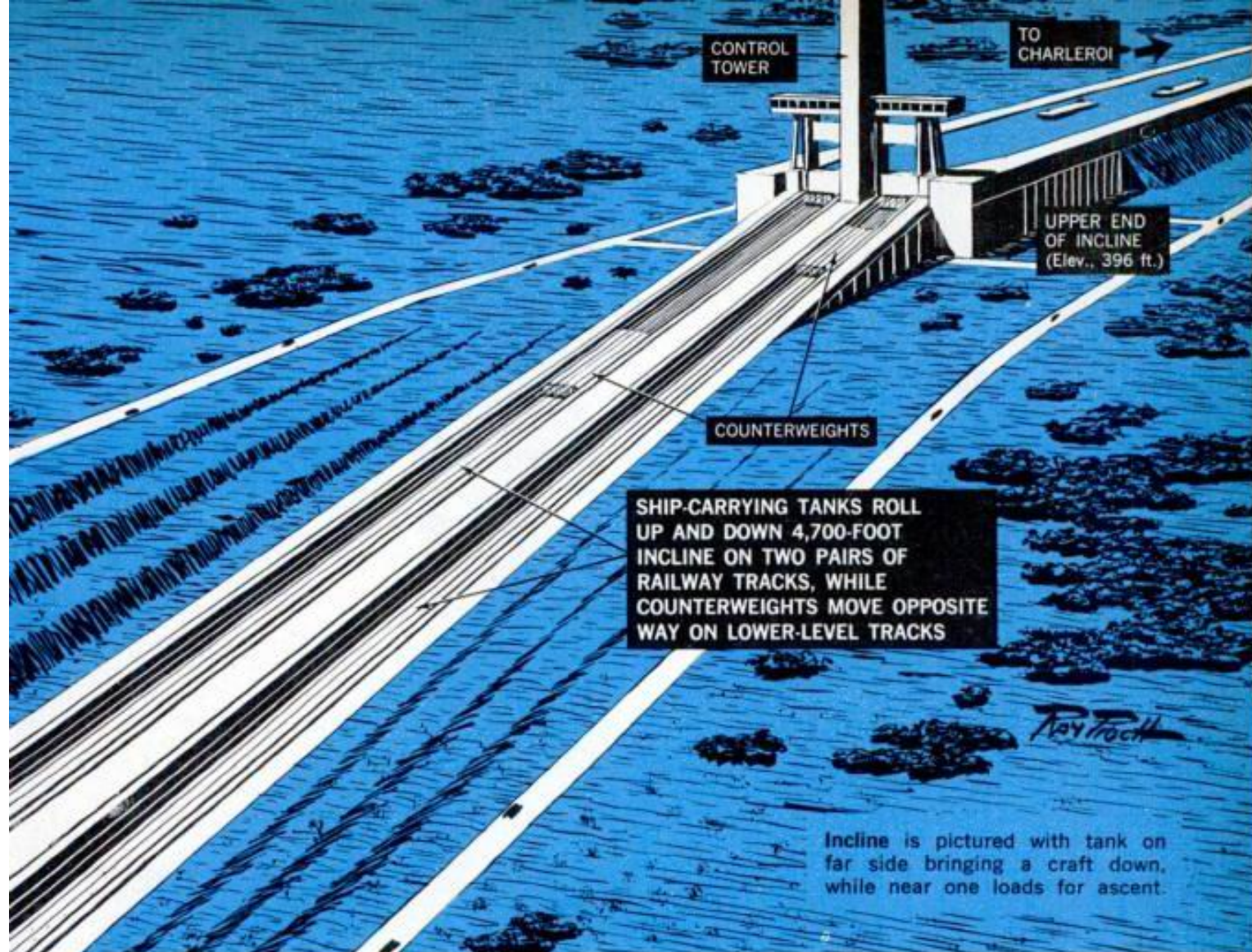
An inclined railway hauls big canal boats over the hill in water-filled tanks

Canal boats as big as 1,500 tons will soon ride up and down a 220-foot hill in Belgium, in a pair of huge water-filled tanks. Each 900-foot-long tank will roll on 236 wheels, at a ponderous 2% m.p.h.,

along a four-rail track on an inclined railway 4,700 feet long.

Nearing completion and due for service early next year, the inclined lift will form a key part of a big-craft canal that will link





Incline is pictured with tank on far side bringing a craft down, while near one loads for ascent.



How incline works: To ascend 220-foot hill, canal boat successively approaches incline, enters tank, is hauled up incline in tank, reaches top, and pro-

ceeds on way. Counterweight (shown in midway position only) balances most of tank's weight. Electric-powered hoist does the rest.

industrial Charleroi with Brussels and the seaport of Antwerp beyond. The new waterway will shorten the winding route of a present small-boat canal and eliminate most of its dozens of locks.

When one of the lift's tanks has been latched to the end of the lower-level canal, and gates are raised, a canal boat is floated right into the tank. Then gates are lowered, the tank is unlatched, and tank and craft are hauled by cables up the five-degree slope. The tank latches to the end of the upper-level canal, gates are raised, and

the boat goes on its way. Reversing this procedure serves for descent.

The two tanks move independently. Their wheels are flangeless to minimize friction; to keep them on the track, extra guide wheels bear against side rails. Counterweights balance most of the tanks' weight and keep the power required for each tank's hoist to a reasonable 1,020 hp., provided by six 125-kw. electric motors. Excess canal water, flowing from the upper level to a hydro plant below, generates the needed current.—David Scott.



World's First Supersonic

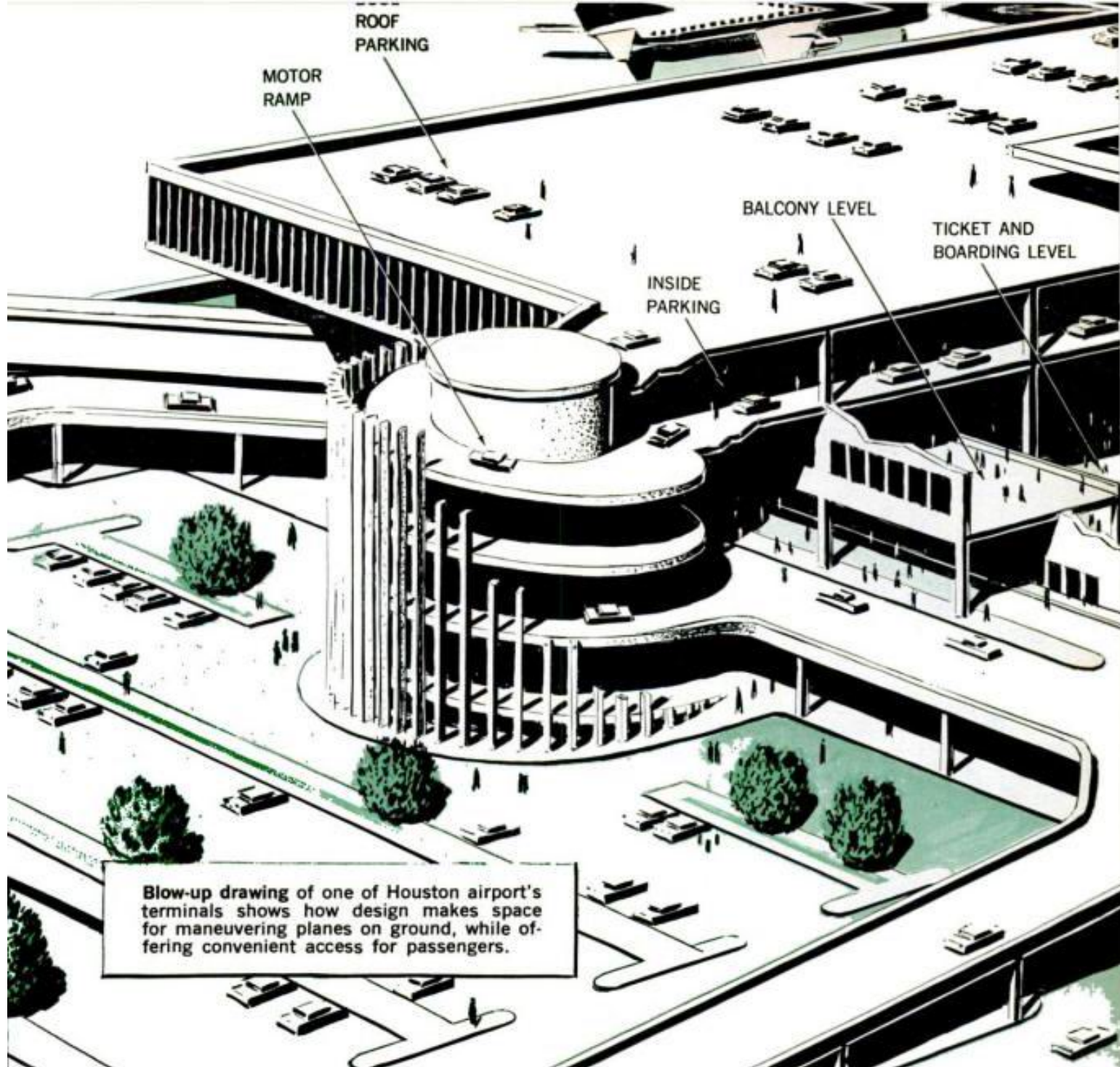
It's big—even by Texas standards.

The Houston Intercontinental Airport site sprawls over 7,000 acres, 16 miles north of the booming city. Slated to open next year, the \$150-million facility will be the first terminal capable of handling the supersonic airliners that are expected to become operational in the mid-70s. The new airport will provide plenty of room for the

huge planes to maneuver on the ground and also be one of the most convenient ever devised for handling passengers.

Houston's director of aviation, Joseph A. Foster, says an airplane terminal is really a connection between two types of transportation: the auto and the airplane.

Despite the long distances between the four terminals in the airport, no passenger



Jet Airport

will have to walk more than 400 feet to or from his car or airport conveyance.

A mile-long air-conditioned tunnel will connect the terminals, as well as a 150-200-room hotel and the parking facilities. Escalators and elevators will speed passengers between levels, while a battery-powered train will carry them between the airport's five major buildings.

Each terminal unit will have four flight stations and 20 gates for boarding planes. The buildings will be sandwiched between two 9,000-foot runway, taxiway, and high-speed turnoff complexes. Eventually the runways will be lengthened to 12,000 feet. Roads around the terminal area will be recessed six feet below flight ramps and deflectors will be installed to keep jet exhausts from blasting passing traffic.

Initially only two units will be opened, but by 1980, the entire airport will be in operation, capable of handling more than six million passengers annually.



Raymond



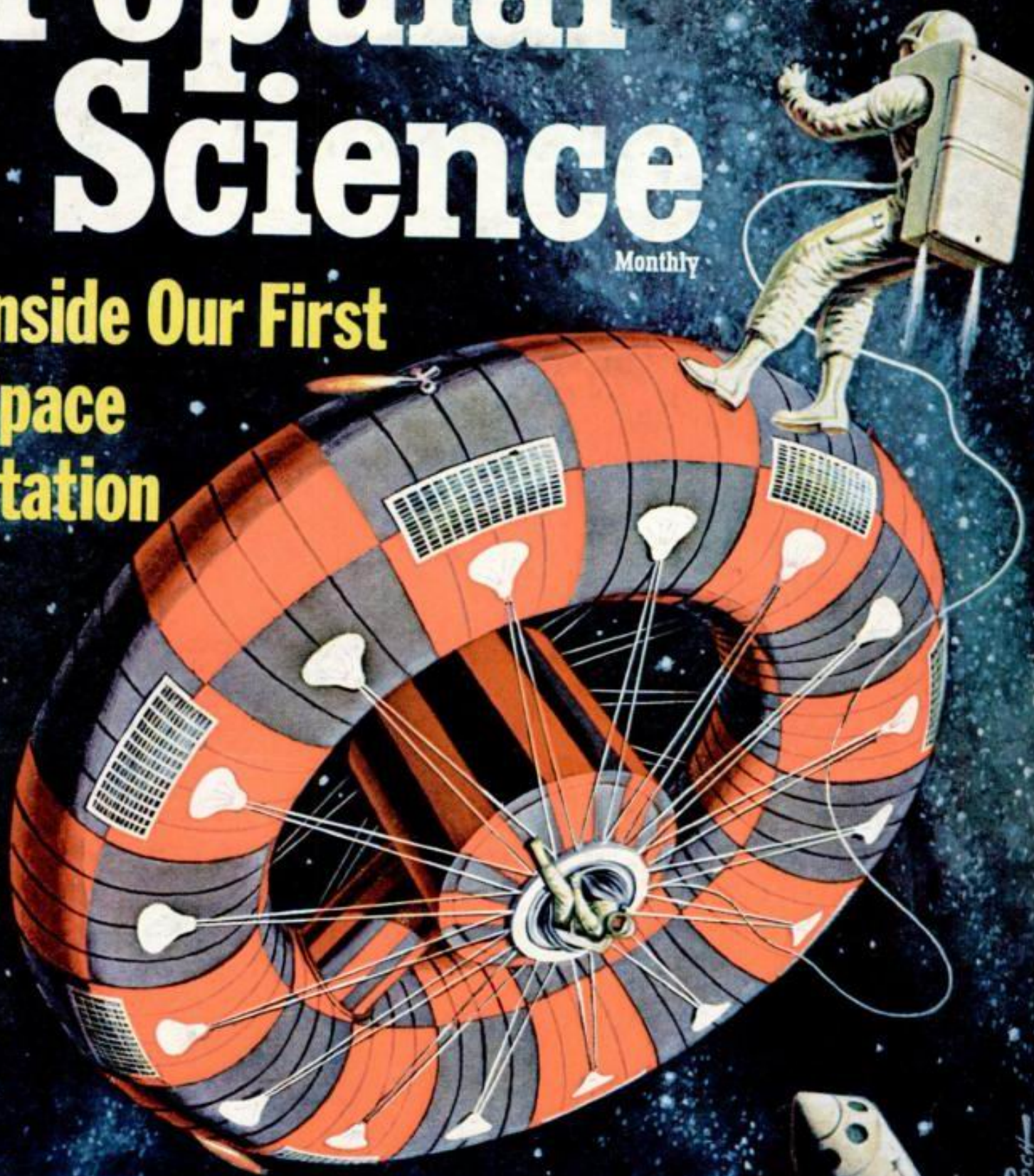
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DECEMBER 1962 35 CENTS

Popular Science

Monthly

Inside Our First
Space
Station



Ray Proctor

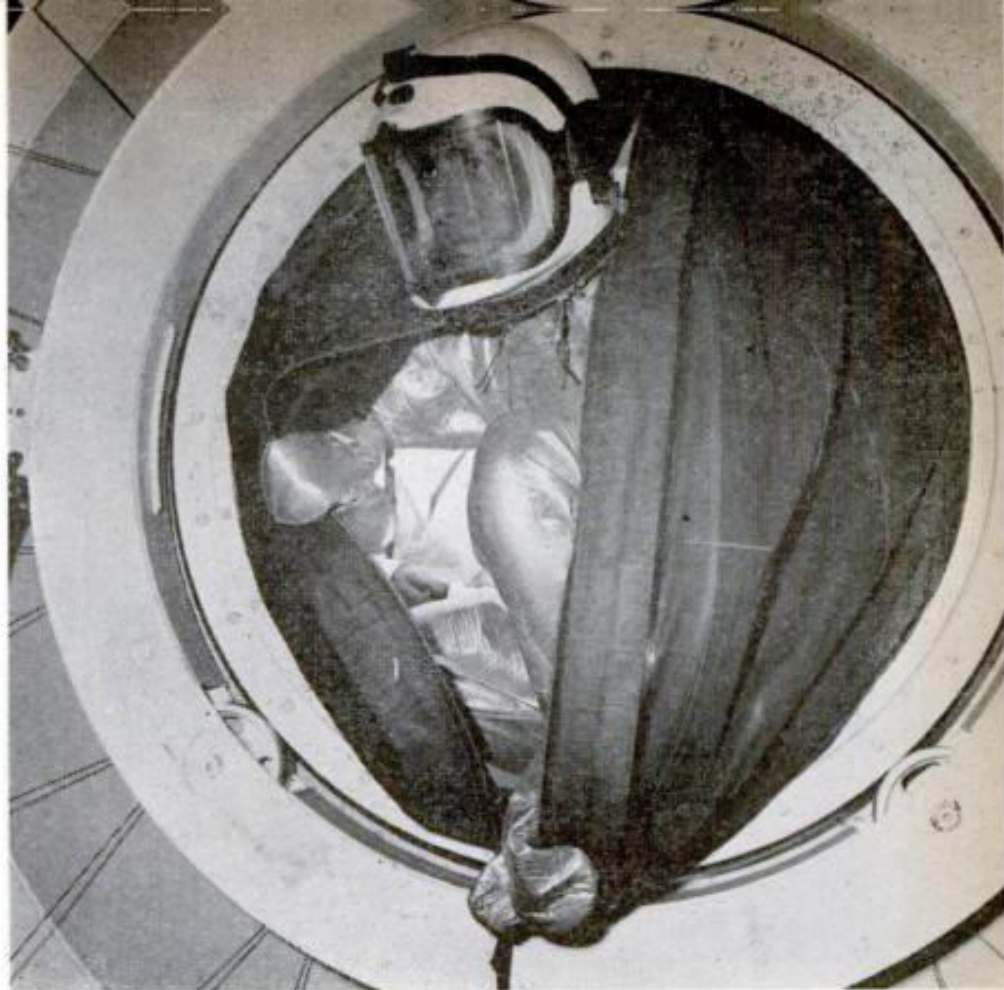
Extra: First Time Ever In a Magazine!
TRY-IT-YOURSELF TEACHING-MACHINE LESSON

Car Features: How to Install a Stick Shift—
Transistor Ignition—Positive Crankcase Ventilation

a full-scale version



To venture forth from space station, you ascend ladder to hub (above). Fully clad in space suit and helmet, you emerge through outer door of airlock (right). A slide fastener opens door or closes and seals it airtight.



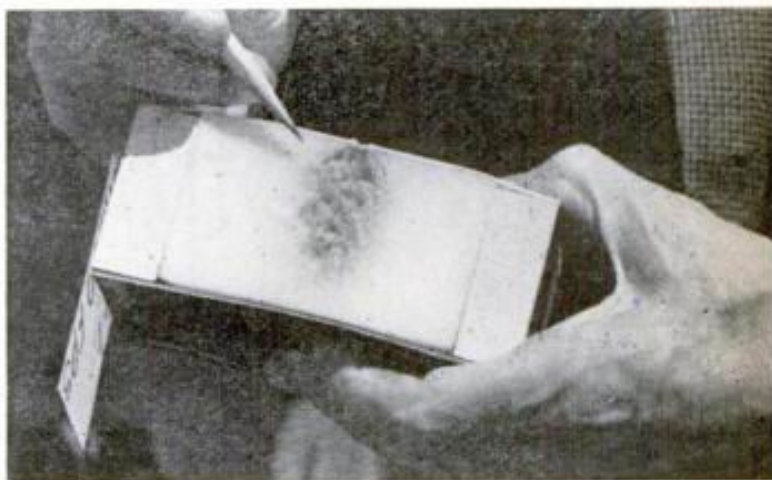
fabric—a curious affair with round holes instead of rungs for footholds. All of these fill with air at the same time that the doughnut inflates itself.

Meals will be tasty and filling—if not exactly gourmet style. A galley will be stocked with weight-saving dehydrated foods in plastic packets, prepared simply by adding hot water. Currently a variety are being developed especially for spacemen. A typical space-station menu: Breakfast of ham and eggs, lunch of chicken and rice, dinner of beef and gravy, all now available in the plastic envelopes.

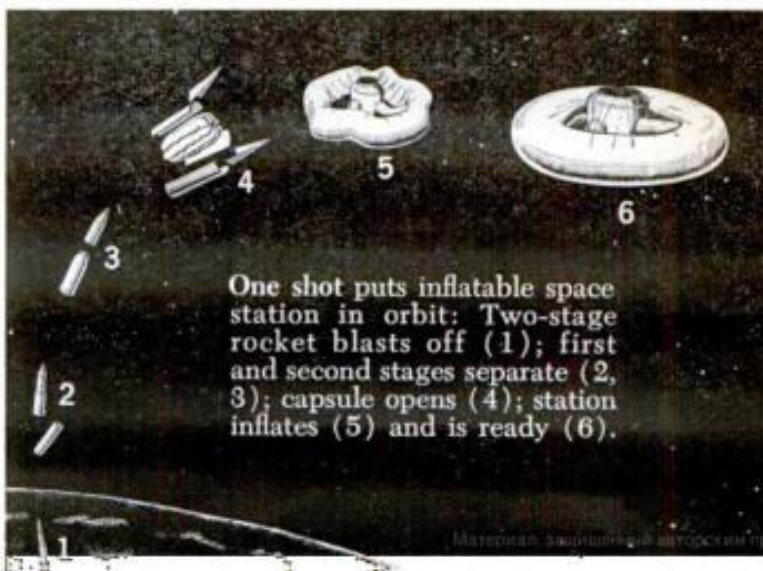
Oxygen and nitrogen tanks in the hub, after inflating the station, will maintain a normal atmosphere and permit natural breathing. "At home" in the living quarters, T-shirts and shorts will be a crew's usual garb. A crewman will don a space suit and helmet only to go outside the station—as he might do to make an inspection or repair.

So far, the doughnut is windowless. Radio and radar will keep the crew in close touch with earth and approaching

[\[Continued on page 174\]](#)



Hazard of meteorites could be met by two-inch thickness of foam rubber, sandwiched between fabric layers of skin. Hit by 14,500-m.p.h. glass pellet, this sample resisted puncture.



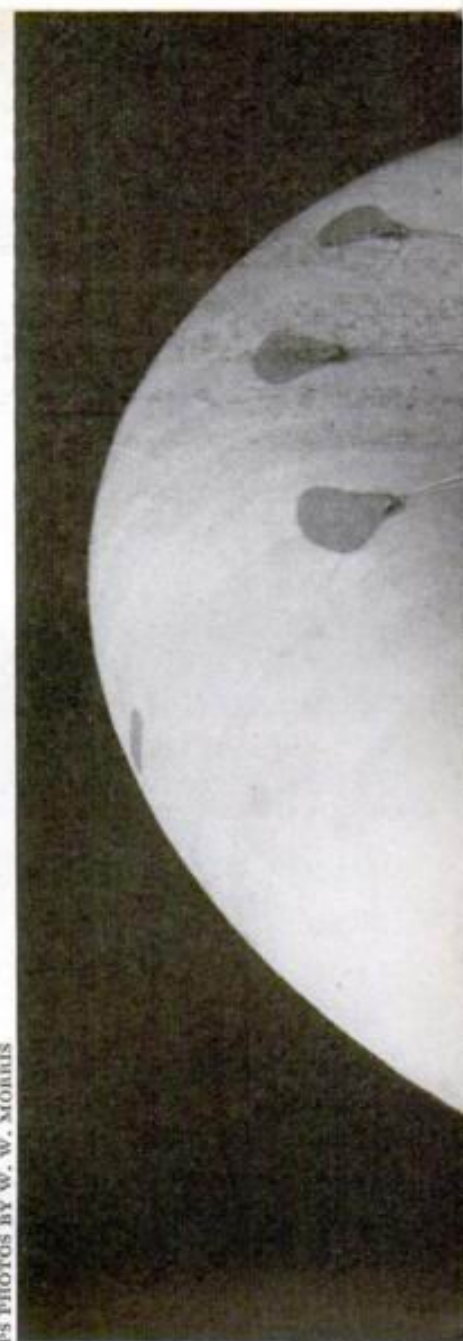
One shot puts inflatable space station in orbit: Two-stage rocket blasts off (1); first and second stages separate (2, 3); capsule opens (4); station inflates (5) and is ready (6).



Inside Our First Space Station



When you walk, or sit at inflated table, "down" is toward rim.



PS PHOTOS BY W. W. MORRIS

Wearing a space suit, you

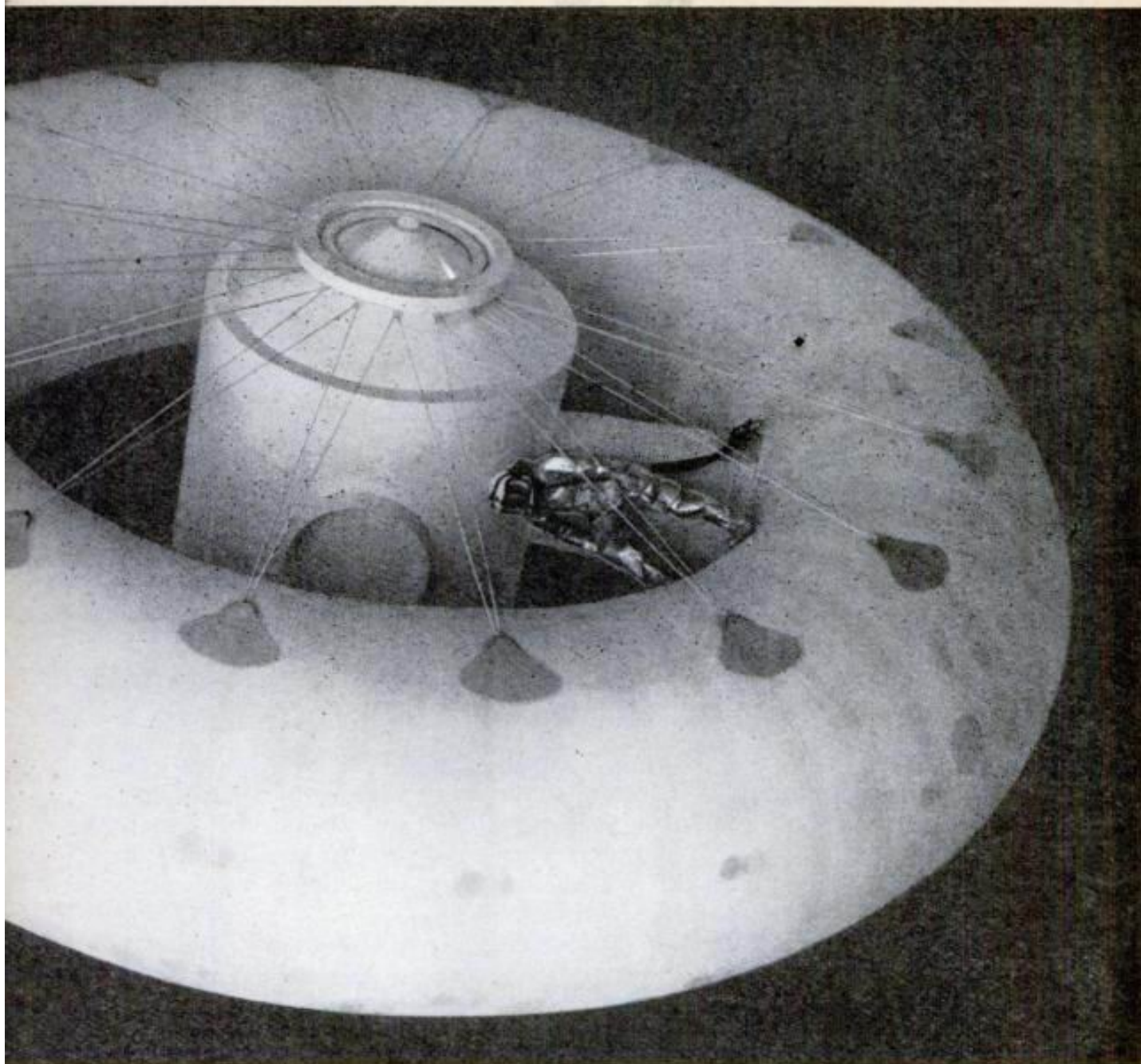
Until now, manned space stations existed only on paper—but here's a full-scale one that could actually be put in the sky

By Alden P. Armagnac

THE strangest dwelling ever built, a gigantic inflated doughnut of rubberized fabric, towers three stories high within an airship hangar at Akron, Ohio. Designed to provide living quarters for 3 to 10 men, the 30-foot-diameter structure is America's first space station—and so far as is known, the first in the world.

Its builder, Goodyear Aircraft Corp., calls it a "full-scale research model" for an inflatable satellite that could be launched into permanent orbit by 1965, to serve as a manned space laboratory and as a way station to the moon and planets.

Its design could readily be scaled up to 150-foot diameter—the size for a space station that its sponsor frankly favors—but the 30-footer itself, Goodyear ex-



can go outside 30-foot "doughnut." Photos have been tilted to show how it would appear in orbit

perts maintain, is a perfectly practical version. With the addition of some finishing touches such as solar-cell panels and jet nozzles, the one in the Akron hangar could actually be launched into orbit and manned.

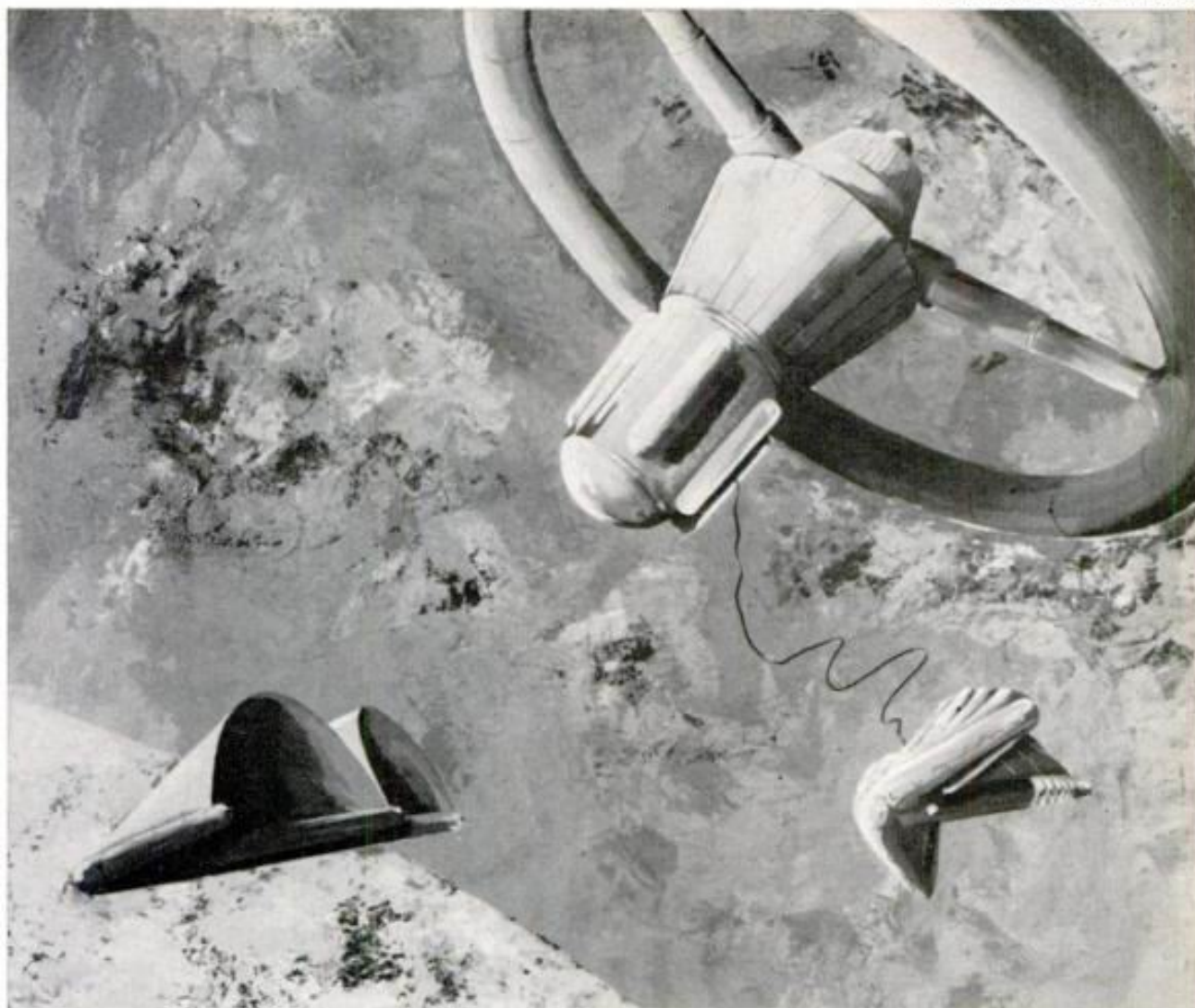
A single rocket shot would put up this 1,800-pound pneumatic dwelling. Deflated and collapsed, it can be packed into the capsule of a rocket such as an Atlas-Centaur, and launched into an orbit 200 to 500 miles high—above the earth's atmosphere, below the Van Allen belts of dangerous radiation. Automatically inflating itself, it will be ready

for occupancy by its crew of spacemen.

Astronauts boosted to its orbit—in Gemini- or Apollo-style capsules—will rendezvous with the space station, enter it through an airlock, and set up house-keeping in space. At intervals of perhaps two to six weeks, a new crew will relieve the previous occupants, who will return to earth.

What will it be like to live in a space station? An inside-and-out tour of the 30-footer—now suspended vertically by its aluminum hub and a single spoke—gives this first-hand view:

You enter the doughnut through a cir-



Paraglider "lifeboat" for safe return from orbit

When a man's duty tour in an orbiting space station ends, he'll want to get back to earth safely. Space-General Corp. proposes fitting inflatable glider wings on tubes that would be resistant to re-entry heat.

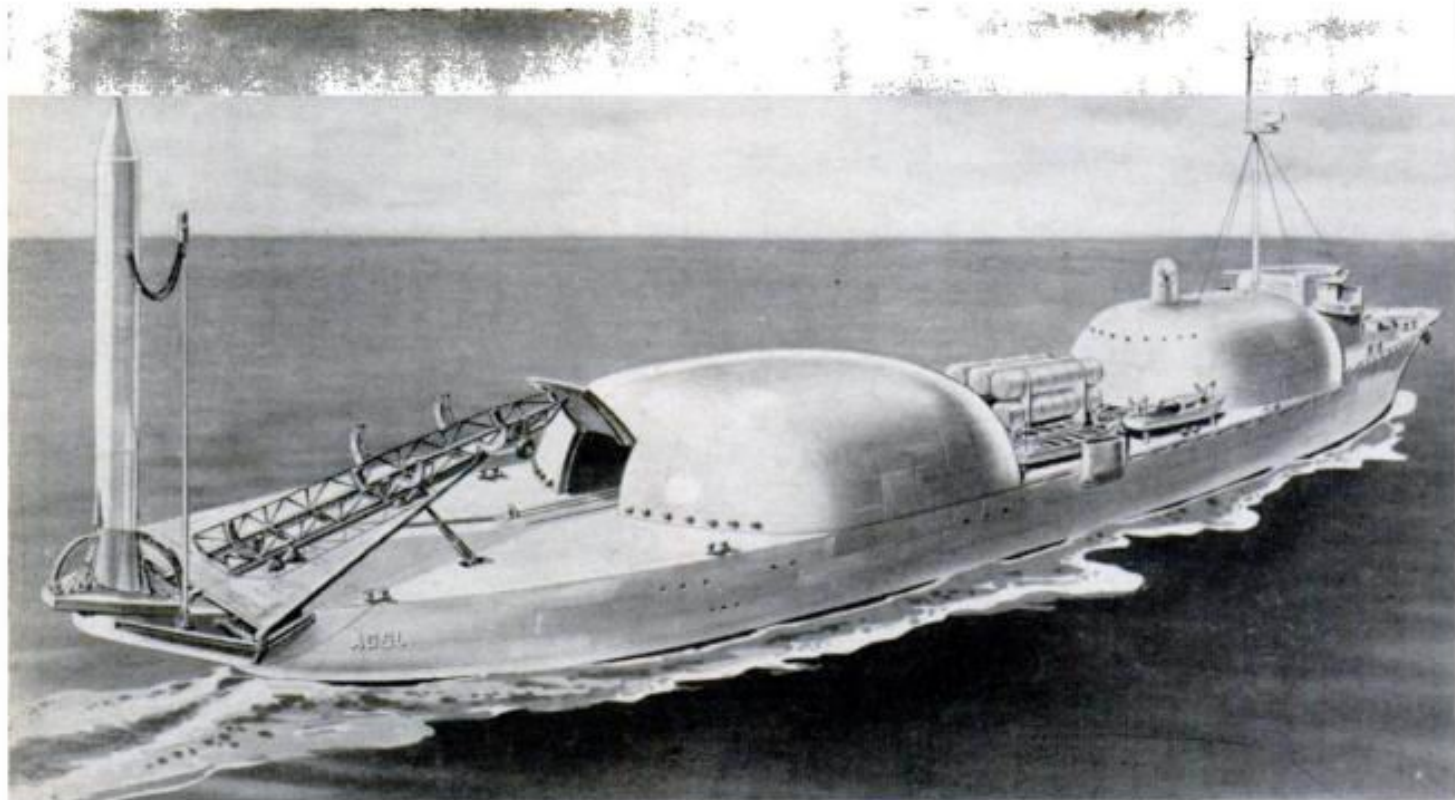
They would be released from the station for return and retrorocketed out of orbit. Two of the one-man space lifeboats are shown above: one gliding towards the earth (left), the other being inflated.

Prehistoric nature trail

The entrance to a unique nature trail displays a map of the route and a sample of exhibits to be found. Along the trail, visitors to the Badlands National Monument in South Dakota see 30-million-year-old fossils of the Oligocene period left in their natural setting but protected by clear-plastic domes. Among them are bones of both extinct mammals and ancestors of some present-day animals.

The trail, off Alt. U.S. 16-A near Norbeck Pass, is a quarter-mile long, takes 20 minutes in an unhurried walk. It was opened to tourists last summer.





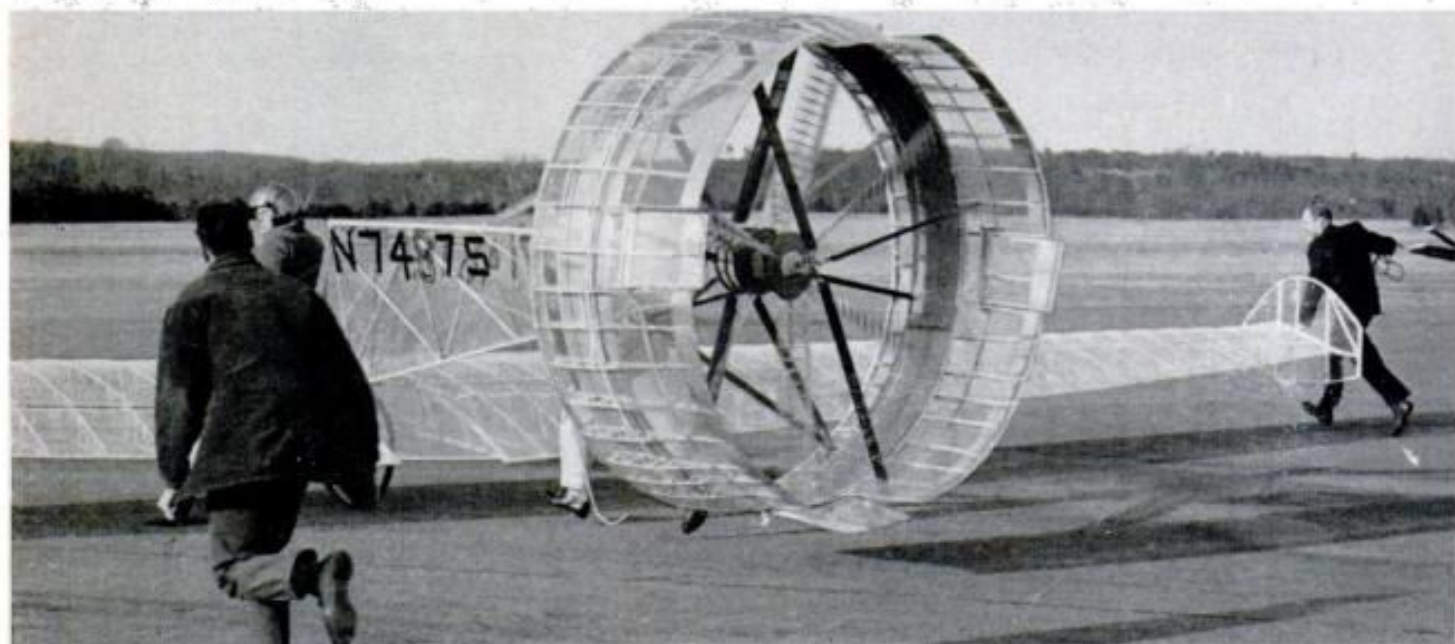
Navy Designs Seagoing Pad to Launch Satellites at Sea

Resembling some futuristic battle wagon, the naval craft pictured here would actually have a peaceful mission. It's a proposed satellite-launching vessel, designed by the U. S. Navy's Bureau of Ships during a recent study of the feasibility of launching space vehicles at sea.

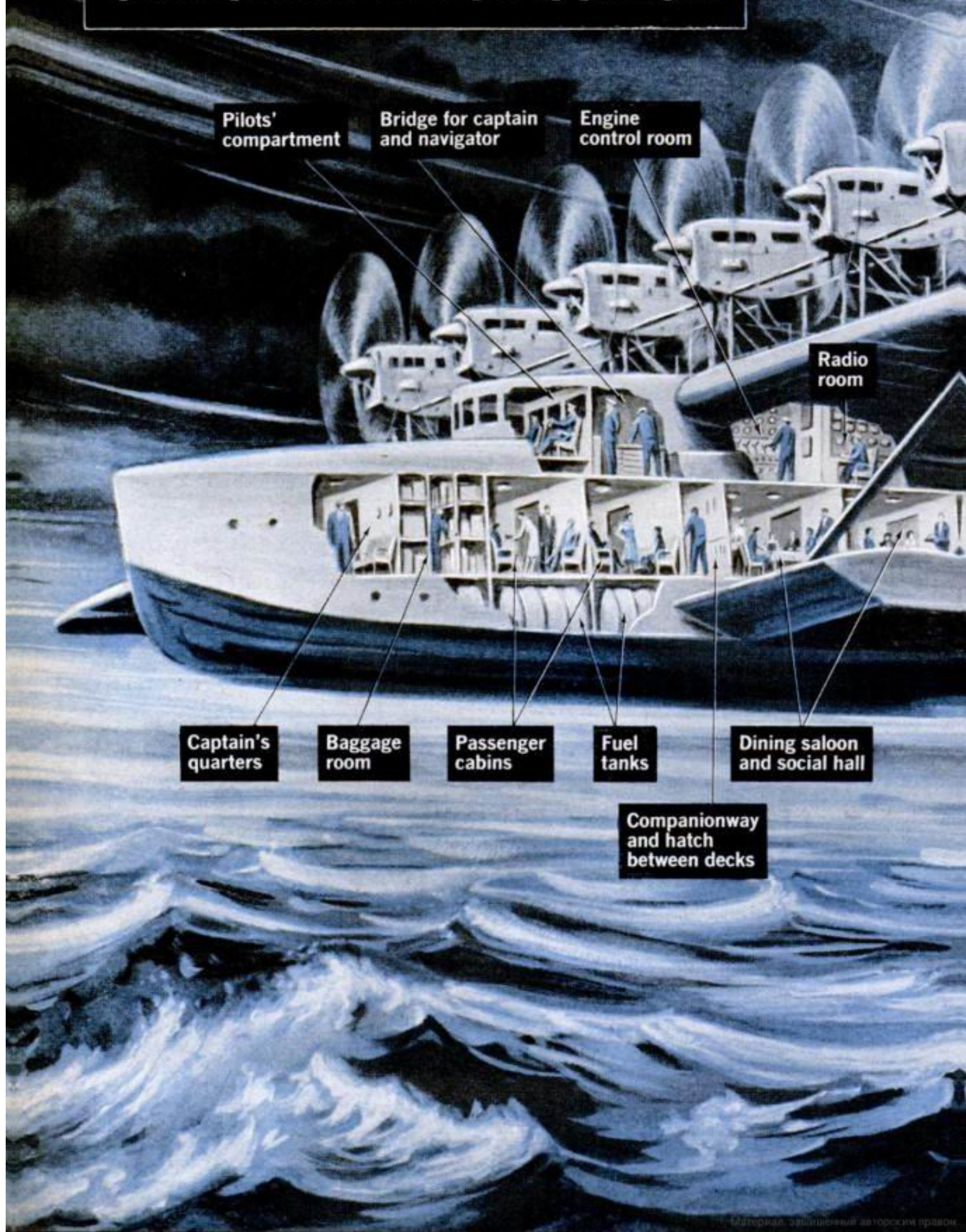
What the Navy envisions is a 17,700-ton

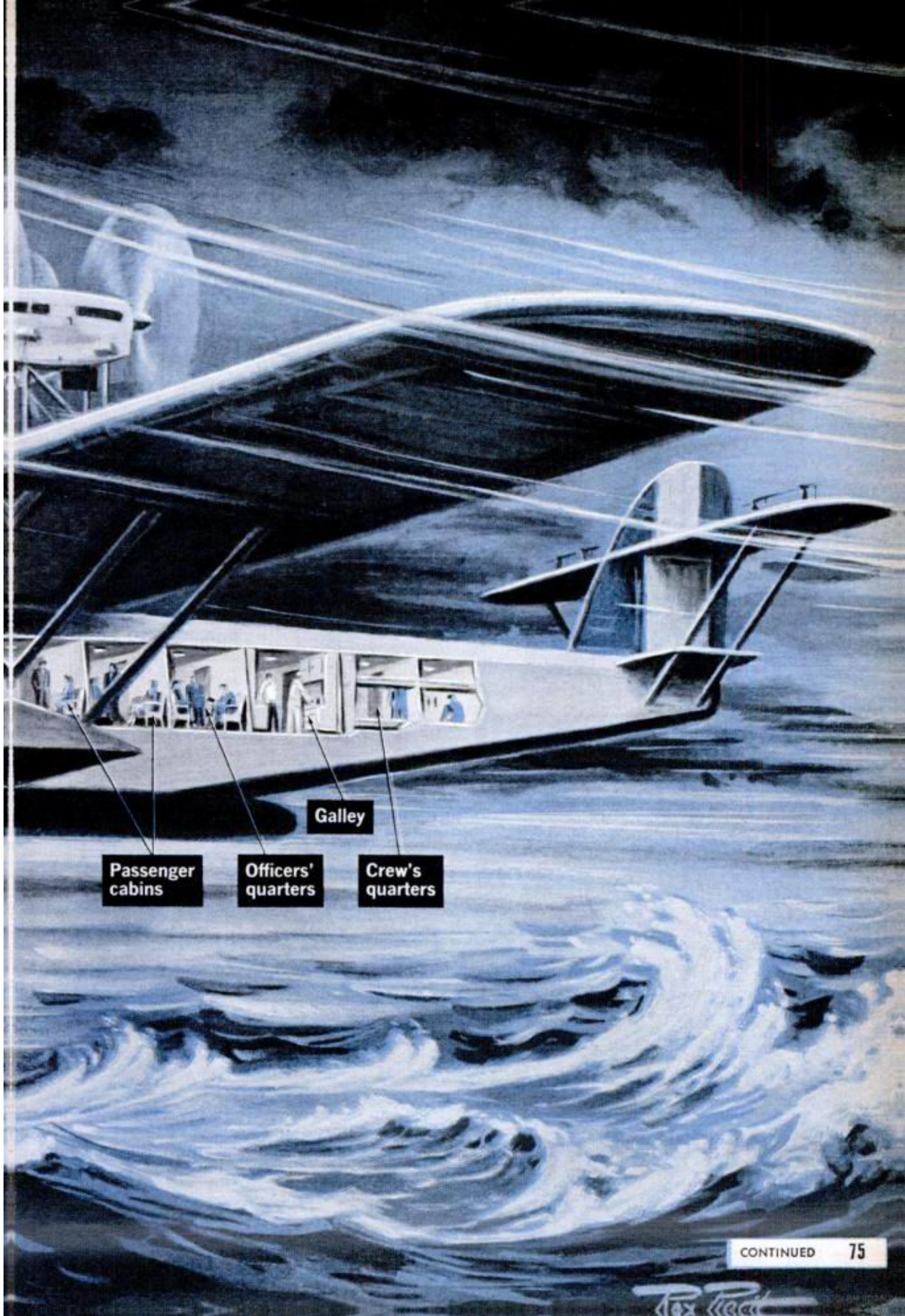
ship with an overall length of 565 feet and a 76-foot beam. It would cruise 10,000 miles at 20 knots.

Bulging above deck, a hangar aft houses up to three satellite-launching rockets. One at a time, they are erected and fired from a launcher hanging out over the stern. Another bulge, forward, serves as a block-



From Rio to New York, the big Dornier Do-X flying boat droned along at around 100 m.p.h., never far from land or high above the waves. It made frequent stops for fuel and to pick up passengers.





Passenger
cabins

Officers'
quarters

Galley

Crew's
quarters

CONTINUED

75

Tex Avery

Like to live in a 60th-story apartment overlooking Lake Michigan, park your car 18 stories high, ride an elevator to your boat? Then move into—

MARINA CITY

By James M. Liston Illustrated by Ray Ploch

THE most spectacular new building in America looks like two stacks of giant poker chips piled on the north bank of the Chicago River.

The twin towers of Marina City represent a cool \$36 million bet that a big idea boldly executed will pay off. The big idea:

- A downtown skyscraper apartment building so close to everything that a man can walk to work.
- A five-building "city within a city" with an exciting atmosphere that gives prestige to the address. In the "basement," or first plaza level, a 700-boat marina (hence Marina City),

CONTINUED

TO BE TOPPED
BY 437 FT.
TV ANTENNA



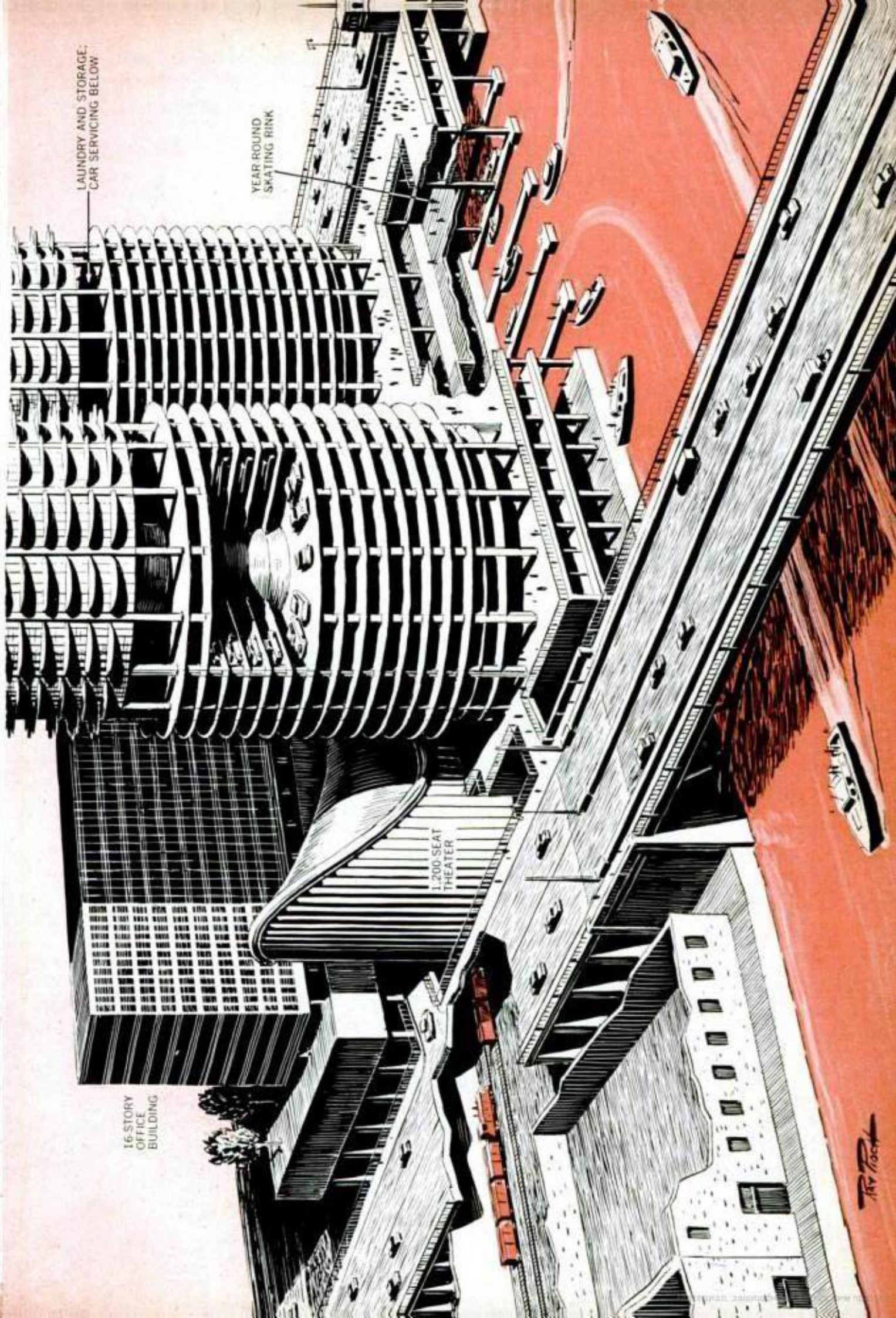
LAUNDRY AND STORAGE;
CAR SERVICING BELOW

YEAR-ROUND
SKATING RINK

1,200-SEAT
THEATER

16-STORY
OFFICE
BUILDING

THE ROCK



Success hinged on getting materials and equipment up

several acres of restaurant and shopping space, a gym, a swimming pool, and an exhibition hall. On the first 19 floors of each tower, spiraling parking ramps for 500 cars; on the 20th, storage and laundry facilities; and above the noise and dirt of the city, 40 floors of apartments. In the "back yard," a year-round skating rink, a 34-lane bowling alley, a 1,200-seat theater, and a 16-story office building on stilts for those who want to limit

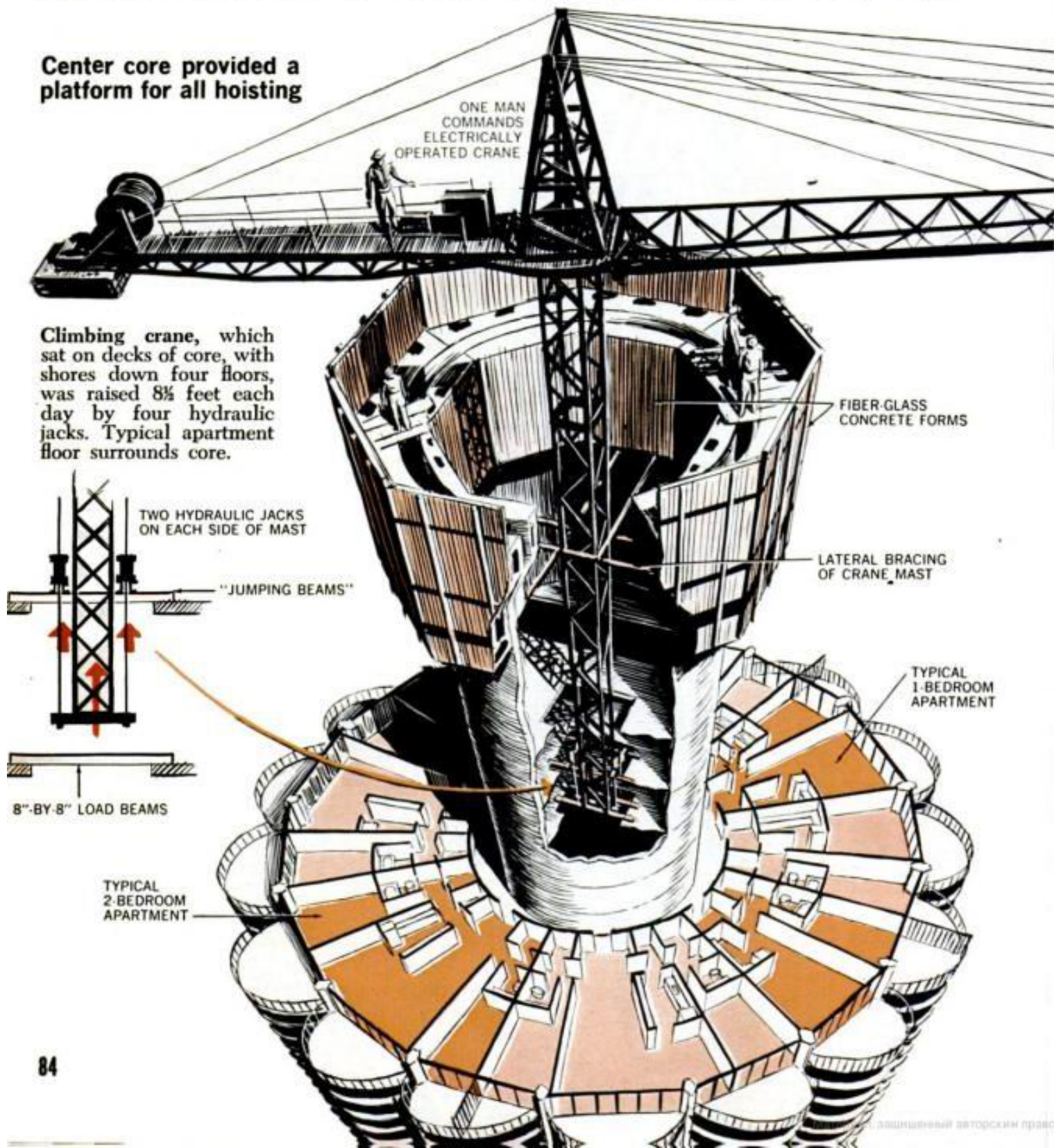
their commuting to a 28-second elevator ride.

● A building that takes city dwellers out of boxes and offers them wedge-shaped rooms expanding toward the horizon, with cantilevered balconies to let them peer down right into the heart of Chicago.

The man who thought he could make it come off is architect Bertrand Goldberg. The investors who bet he could

Center core provided a platform for all hoisting

Climbing crane, which sat on decks of core, with shores down four floors, was raised 8½ feet each day by four hydraulic jacks. Typical apartment floor surrounds core.

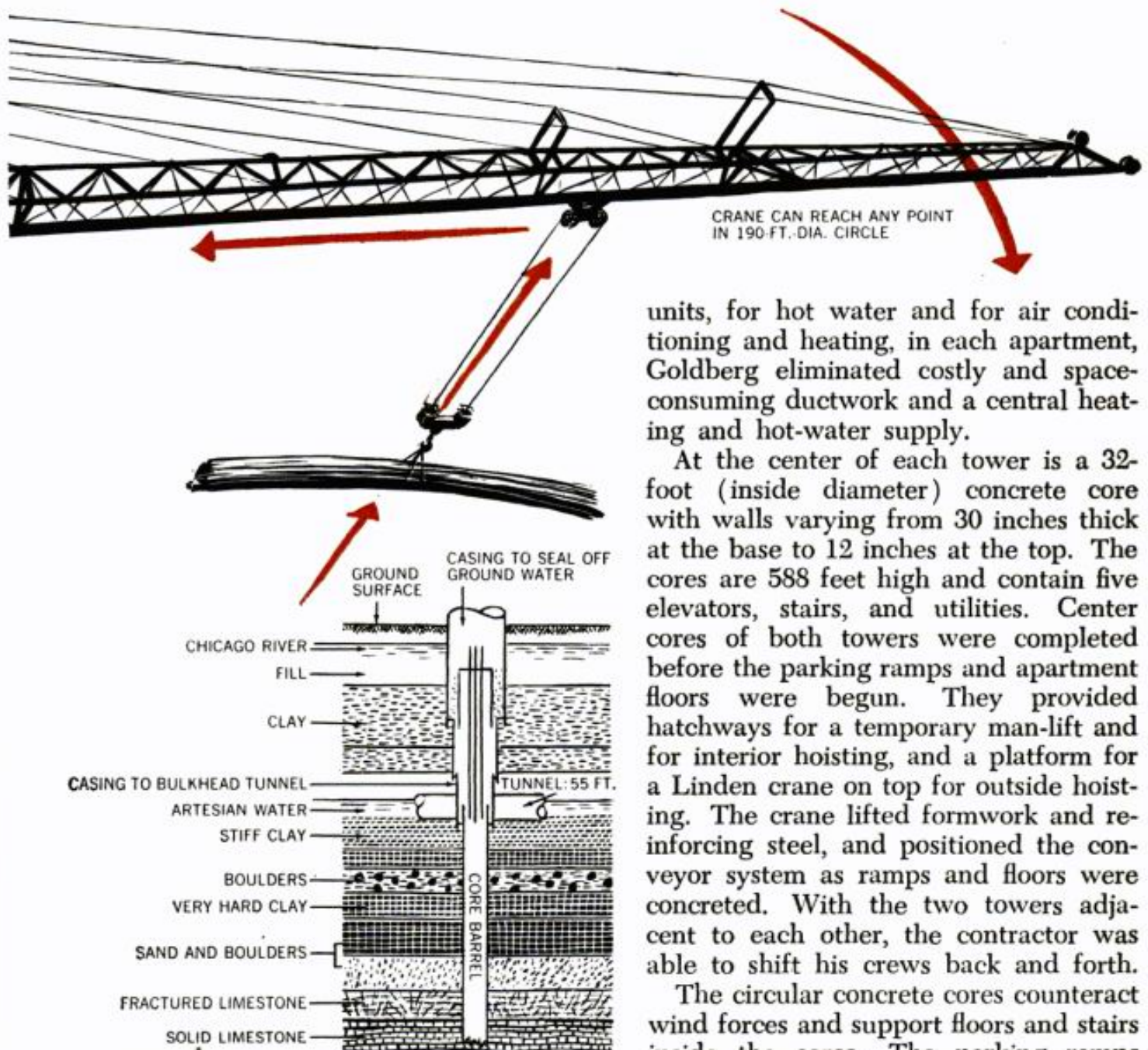


into the air as the job rose. Solution: the Linden crane

are the Building Service Employees International (the janitors' union), a string of banks, and the FHA. Wags call it "the house the janitors built." Few janitors can afford to live in it (rents range from \$115 for an efficiency apartment to \$350 for two bedrooms), but the project benefits the union funds.

Why round? Goldberg used a circular form for the high-rise towers of the five-building complex because: 1) It gave the

highest ratio of usable floor space to exterior skin. 2) It reduces actual wind loads and the wind stresses that the building code requires be taken into account. 3) The circular shape reduces the length of supply and return runs for utilities. Since all utilities—heat, air conditioning, cooking, and hot water—are serviced by electricity, only electricity, cold water, and telephone had to be supplied to each tenant. With individual



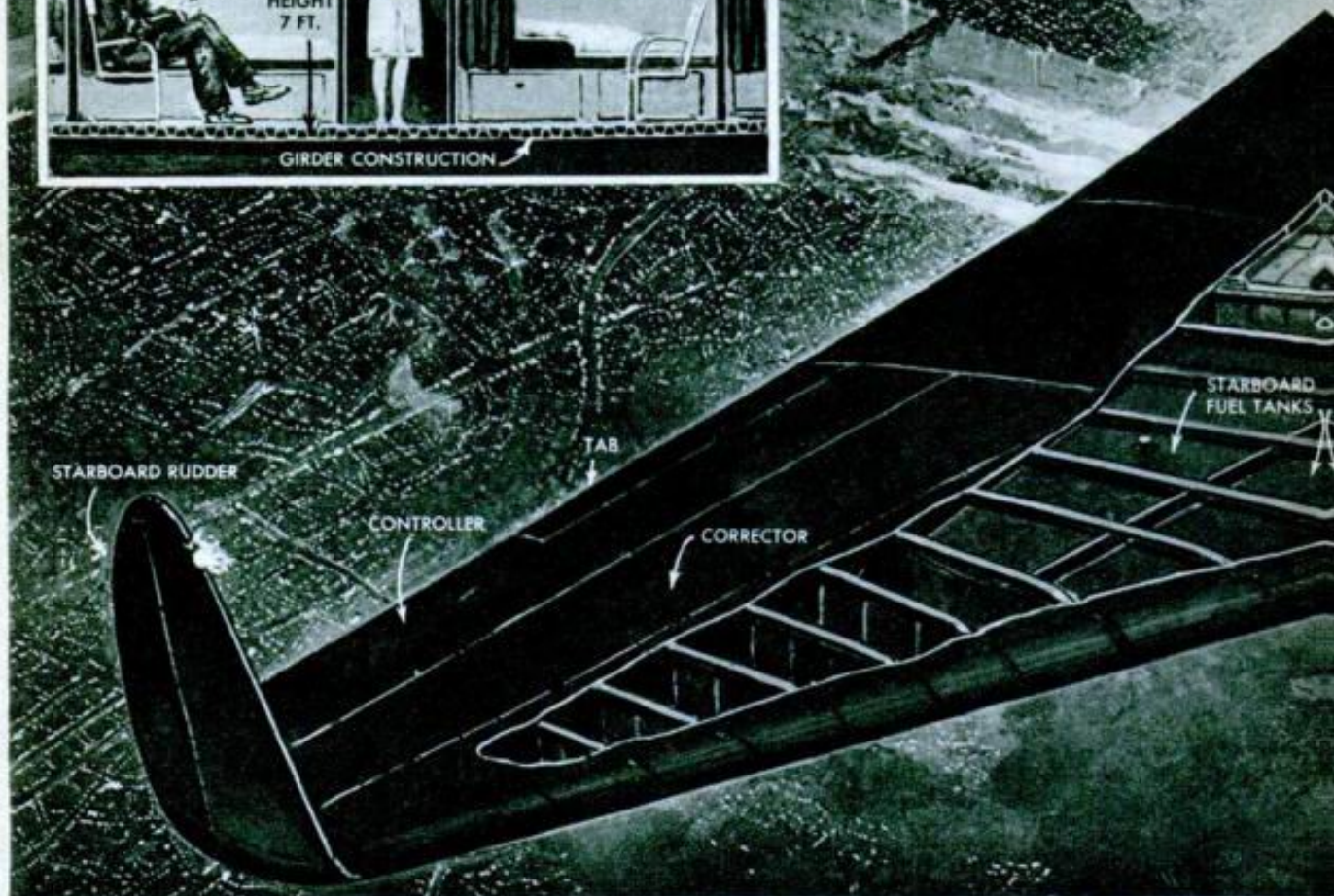
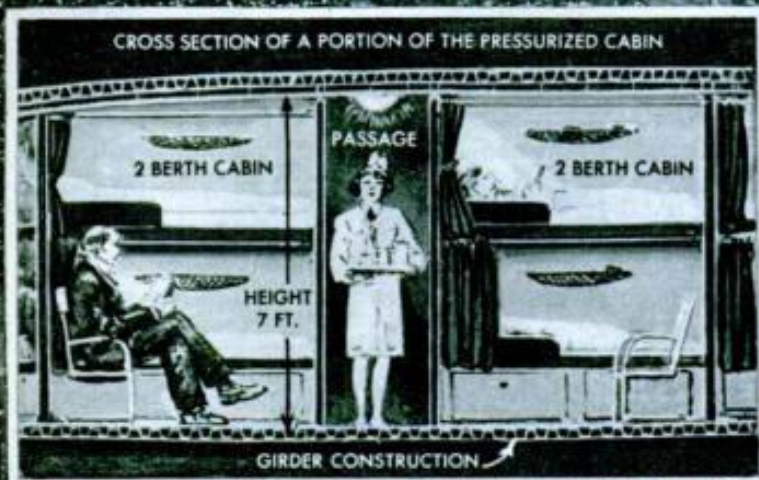
Steel-core barrel caissons (158 were installed) penetrated fill to limestone. Water-filled tunnel was sealed with steel-shell bulkhead.

units, for hot water and for air conditioning and heating, in each apartment, Goldberg eliminated costly and space-consuming ductwork and a central heating and hot-water supply.

At the center of each tower is a 32-foot (inside diameter) concrete core with walls varying from 30 inches thick at the base to 12 inches at the top. The cores are 588 feet high and contain five elevators, stairs, and utilities. Center cores of both towers were completed before the parking ramps and apartment floors were begun. They provided hatchways for a temporary man-lift and for interior hoisting, and a platform for a Linden crane on top for outside hoisting. The crane lifted formwork and reinforcing steel, and positioned the conveyor system as ramps and floors were concreted. With the two towers adjacent to each other, the contractor was able to shift his crews back and forth.

The circular concrete cores counteract wind forces and support floors and stairs inside the cores. The parking ramps and apartment floors are supported by

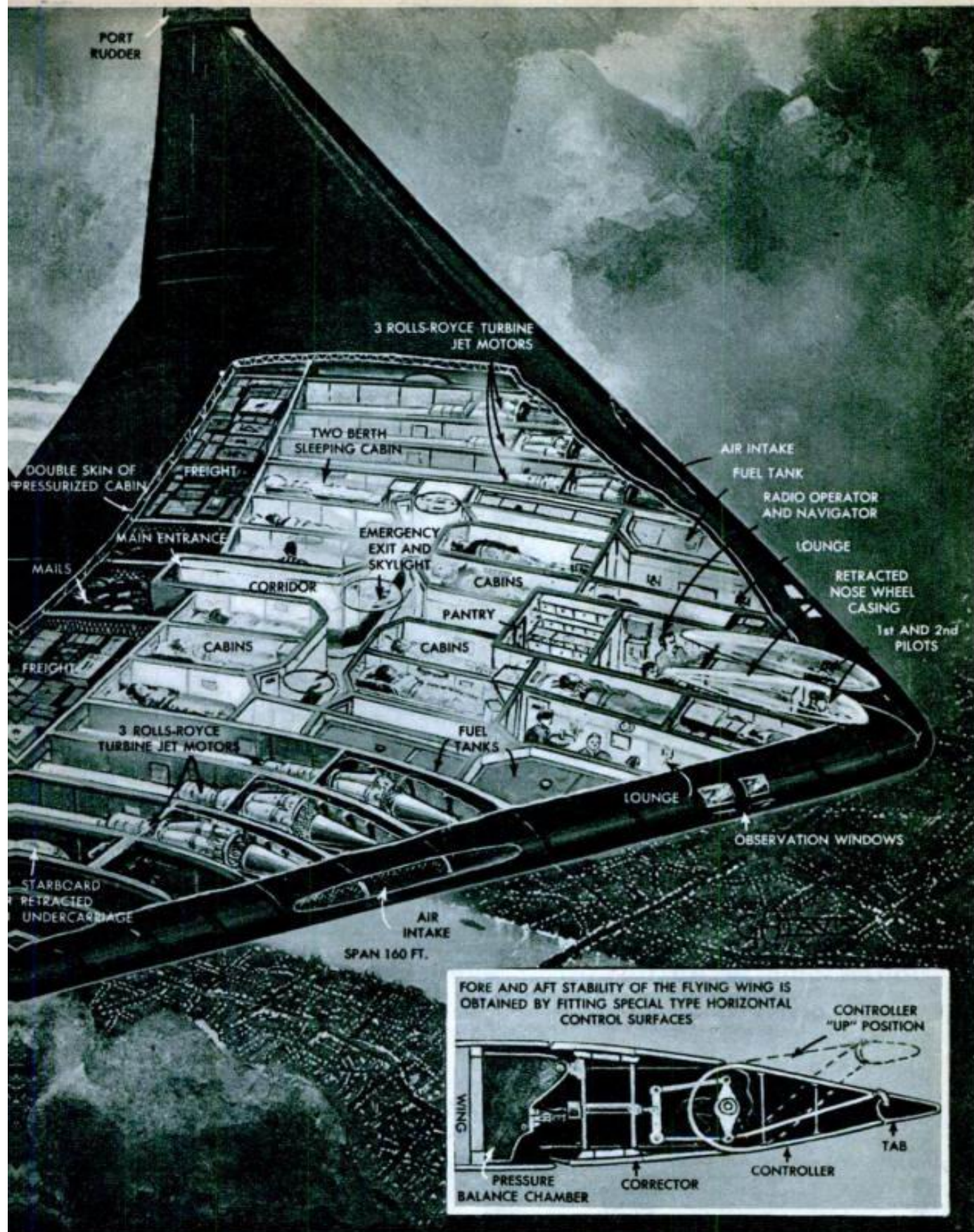
[Continued on page 194]



Transatlantic Flying Wing

PASSENGERS who want to drop off to sleep in their berths in England and awoken in America the next morning may soon flash across the Atlantic in a British-designed flying wing. The huge V-shaped

plane will be jet-propelled and will carry from 24 to 28 passengers, part of a pay load of 29,000 pounds. Top speed will be more than 400 miles an hour. Both the cabin and the cargo compartments will be pressur-



ized to withstand high-altitude flights. Guinea pig for the big tailless aircraft is a 6000-pound glider (see inset photo) of similar construction that has been put through a series of test flights by the Armstrong-Whitworth Company. Construction was started on the flying wing when the glider proved its airworthiness. Six Rolls-Royce

turbine-jet motors will power the plane. A novel feature is a combined aileron-elevator that pinch-hits for the tail assembly used to stabilize conventional planes. Rudders are retained on the wing tips. Wing span will be 160 feet with a total wing area of 4400 square feet, and the fuel tanks will have a capacity of 10,000 gallons.



X-WING SAILBOAT

P. 64

The Shape-Shifting Solar-Powered Luxury Yacht

MIND CONTROL?

What a Mysterious Military Facility Is Really Up To P. 60

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FUTURE
NOW

33 HOT
PRODUCTS



THE FUTURE OF THE ENVIRONMENT

ECO-TROPOLIS

A BLUEPRINT FOR FRESH AIR + PRISTINE WATER + CHEAP ENERGY

PLUS **48**

Audacious Ideas
To Save the
Planet*

*And One Cautionary Tale (P. 54)



JULY 2008

US \$4.99

GREEN MEGALOPOLIS



An eco-savvy blueprint for tomorrow's megacity points the way to fresh air, clean water and traffic that never jams

LATER THIS YEAR, for the first time in history, more than half the world will live in cities. And that trend shows no signs of slowing. By 2030, there will be five billion urban souls—up from 3.3 billion today—as the developing world's rural populace migrates to cities, seeking better education and higher-paying jobs.

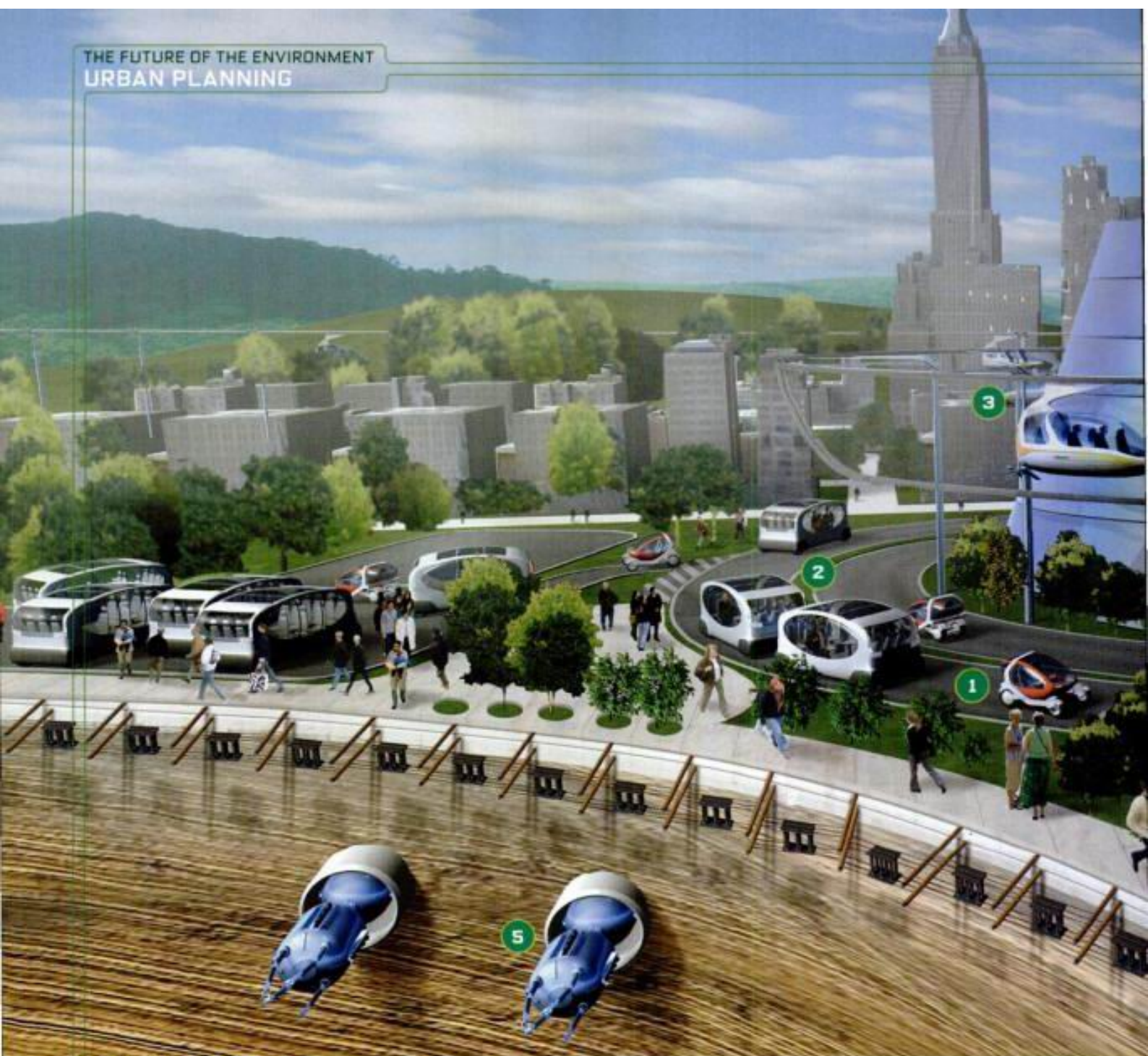
The inevitable result is the megacity, a monster urban infrastructure already roaring to life in Asia and Africa. In China, for example, Dongguan, just a midsize town 20 years ago, now has about seven million residents. Even more extreme, the population of Lagos, the former capital of Nigeria, is expected to hit 24 million by 2015, up from three million in the 1970s.

Such growth poses profound ecological problems. Young metropolises will be nightmarish if they become Mexico City, with its population of 18 million, where 40 percent of the city's drinking water is lost to shoddy plumbing, and residents sickened by air pollution collectively lose 2.5 million working days a year.

But cities don't have to be this way—and at their best, they're the exact opposite. Urban density and rational cen-

tral planning are actually the first, most important steps in eco-minded living. Take New York: A Gothamite produces two thirds less carbon emissions than the average American, mostly because of mass transportation. Heating is also highly efficient because it's radiant and shared between apartments. And major green initiatives, such as New York City mayor Michael Bloomberg's plan to reduce the city's carbon emissions by 30 percent by 2030, are under way. For New Urbanists, city planners who have long promoted such goals, that's close to ideal.

But what does the *perfect* megacity look like? On the following pages, you'll find a showcase of the most visionary ideas put forth by scientists, engineers and designers. The solutions include automated, on-demand buses, levitating commuter pods, skyscraper farms, paint-on solar cells and tidal-energy generators. Some will take 50 years to go commercial. But all of them suggest a future in which green technology will make cities what they were meant to be all along: sustainable. —CLIFF KUANG
ILLUSTRATION BY KEVIN HAND



KEY TO THE CITY Your guide to tomorrow's urban landscape

TRANSPORTATION

POD CARS The electric City Car [1], inspired by researchers at the Massachusetts Institute of Technology, works like a grocery cart at the supermarket. Pull the two-seater from a stack near any major hub—say, a subway entrance—and drive it to a depot near your destination, park it, and forget it. Unlike today's cars, which sit unused 95 percent of the day

and hog precious parking space, the pods fold up during storage. The City Car's most ingenious aspect is that it offers a new template for energy distribution: It charges with solar panels on the roof, and pumps excess energy into the grid while parked.

DRIVERLESS BUS

In an effort to reduce congestion and pollution, the city employs a fleet of autonomous buses

[2] powered by a mix of biodiesel and electricity. The bus finds its way to passengers by following magnets embedded in dedicated lanes while a central computer controls on-demand routing, service frequency and total route capacity.

ENERGY HIGHWAYS

Save energy by driving faster. Wind turbines [14, PAGE 53] invented by architect Mark Oberholzer

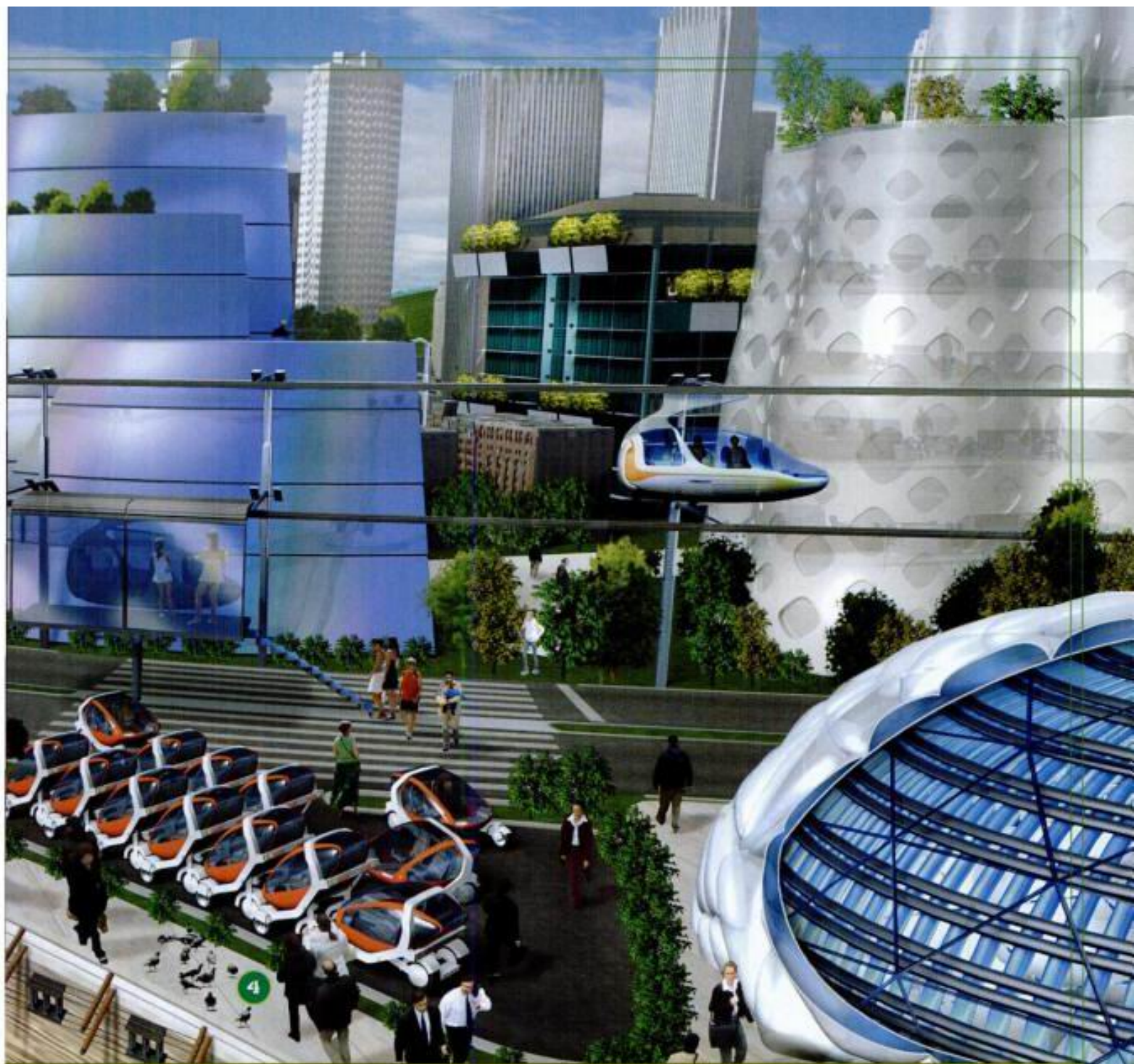
line all the highway medians, generating power for the urban grid as you whoosh past them.

MAGLEV Skytran, an on-demand maglev railway system [3] from California start-up Unimodal, can carry up to 14,400 people an hour—as many as a three-lane highway. Individual two-seater pods zip along a single high-speed guideway at speeds of up

to 150 mph. When they reach their destination, they pull into a pit lane—located at quarter-mile intervals—lined with arrival and departure portals. The railway itself is lined with magnetic coils, and the pods feature permanent magnets rather than energy-hogging electromagnets. Altogether, the system would cost \$10 million a mile to build, a tenth of its light-rail equivalent.

RECREATION

ALGAE PARKS The Algae Power Park [15] is a 3,600-square-foot pond coated with a breed of algae engineered at the University of California at Berkeley to produce a million times as much hydrogen gas as natural algae does. To do so, the plants are shunted to a chamber below the pond, where they're deprived of oxygen and sulfur. The resulting hydrogen is then



MORE CITY ►►►

collected and siphoned into balloon-like tanks. One balloon could hold enough energy to power 12 cars for a week.

POWER SIDEWALKS

The Crowd Farm **[4]**, proposed by architects James Graham and Thaddeus Jusczyk, gathers energy from the countless footfalls that strike the city's sidewalks. It works like a dynamo: Blocks installed beneath the

sidewalk depress slightly under the force of weight and slide against each other, while a device converts the resulting energy into an electric current. If installed in a busy train station, the Crowd Farm could power 6,500 LEDs—enough to light the building.

FOOD AND DRINK THE OCEAN ON TAP

With less than 1 percent of the Earth's water

available for consumption, freshwater shortages are bound to plague major cities. Fortunately, materials scientist Eric Hoek of the University of California at Los Angeles has created a seawater-desalination system **[16]** that turns the oceans into one big watercooler. Hoek's invention is a membrane of tubes, each one 1/100,000 as thin as a human hair. Too narrow for salt, the tubes act like fast lanes

for freshwater. A coating of hydrophilic polymers helps pull water through but repels everything else, bacteria included. Hoek's early tests indicate that his membranes are 50 percent more efficient than conventional steam-based desalination systems.

TUNNEL 'BOTS

A major city like New York can lose 4 percent of its water supply every day, which amounts to 34 mil-

lion gallons. To spot and repair leaks, researchers at the Woods Hole Oceanographic Institution have developed an autonomous underwater robot **[5]** equipped with video cameras and sonar to survey water pipelines.

VERTICAL FARMS

Agriculture is the single biggest contributor to global warming. And organic food? The fossil fuels involved in transpor-

tation and cultivation tend to wipe out any ecological gains. A better solution is to grow our produce right where we live. The vertical farm, inspired by Israeli company Organitech, is a 30-story, robotically tended hydroponic oasis **[6]** that produces food and water for 50,000 people. Vegetables float in Styrofoam trays on an automated nutrient track that moves them along

CONTINUED ►

THE FUTURE OF THE ENVIRONMENT URBAN PLANNING



KEY TO THE CITY Your guide to tomorrow's urban landscape

from stations that plant, tend, and finally harvest them. Irrigation comes from filtered sewage, purified by a tower of zebra mussels. In turn, the water nourishes more than 100 varieties of plants, from broccoli to bananas.

LANDMARKS

GREEN TOWER This building [7], based on a design by French architect Jacques Ferrier, is 10 stories of ecological responsi-

bility. An exterior concrete lattice, which carries the building's structural load, houses photovoltaic cells and rainwater channels. The latter funnel water to a central purification system and provide clean water for the building. Up top, there could be a wind farm, and below, geothermal wells that eliminate the need for air conditioners and boilers, using the constant temperature of the bedrock to cool water

in the summer and heat it during the winter.

BUBBLE HOUSE

Residential buildings [8] conceived by San Francisco-based architecture firm IwamotoScott do double duty as water filters, making tap water plentiful and safe to drink. The technology relies on an intelligent "water jacket"—a thick, porous skin that wraps around the building's facade and

funnels rainwater into hollow struts, where it's purified by ultraviolet light. On top of the building are "pillows" filled with a salt solution. When it's warm outside, the salt turns to liquid and absorbs heat, providing ambient cooling; when cold, it solidifies, releasing heat and acting as insulation.

REFUELING

SUPERGRID The Supergrid [9], proposed

by Jesse Ausubel of the Rockefeller University, couples superconducting electrical cables with a hydrogen pipeline. The cold liquid hydrogen flows through a network of pipes, cooling the cables and reducing energy loss due to resistance. The pipeline also doubles as an easy way to distribute hydrogen for transportation.

ENERGY PAINT

Virtually every building

generates much of its own power, thanks to affordable paint-on organic solar cells [10]. Invented by chemist Somenath Mitra of the New Jersey Institute of Technology, the viscous solution contains two types of nanoparticles—one that traps the sunlight and another that converts it to electricity.

WIND FARMS

Existing wind turbines are limited by their mechan-



ics, since their bearings often wear down. The maglev turbine **111**, unveiled last year at the Wind Power Asia exhibition in Beijing, solves this problem. A set of vertical fins rests on permanent magnets made from neodymium—no energy goes into electromagnets. With no bearings and minimal friction, the turbines could start churning at wind speeds as slow as 2 mph. A single

maglev turbine could produce enough power for 800,000 homes.

WATERFRONT TIDAL TURBINES

Scientists estimate that the ocean could provide two terawatts of energy, about 12 percent of the world's total consumption. One option to harness that power is tidal turbines **112**. Sea Generation in Bristol, England, is now install-

ing the world's largest tide-harnessing turbine in a channel off the coast of Ireland, where it generates enough to light up 1,000 homes. Embedded on the sea bottom at a depth of up to 130 feet (depending on the tide), it works like a windmill. Incoming tidal current turns the rotors, which power a motor and a generator. When the tide flows out, the rotor blades

reverse direction by turning on spindles. Next up is a 10.5-megawatt seven-turbine installation being developed off the coast of Wales.

WAVE MACHINES

Another option is the Wavebob **113**, which turns waves into electricity. It has two basic pieces: a central column attached to a submerged weight, and a lightweight ring

surrounding that column that floats at the surface of the water. As waves come in, the outer ring bobs much more quickly than the slower-moving central column. The two parts are connected by hydraulics that pressurize a stream of oil, which drives an electrical generator. The device monitors wave conditions to tune its hydraulic resistance to optimize power generation or to

decouple the column and ring when rough seas threaten to tear the assembly apart. This summer, the company behind the device (also called Wavebob) will complete trials on its final quarter-scale model in Ireland's Galway Bay, and by 2010 it will have a full-scale prototype that generates 1.5 megawatts. Says Andrew Parish, Wavebob's CEO, "Where the surfers go, we'll follow."

Straight-Line Electric Motor Promises 200-m.p.h. Train

RAILROAD TRAINS run in straight lines, but their electric drive motors, strangely, spin in circles. And it takes mechanical gymnastics to convert one motion into the other. The logical question then is: Why not make a motor that gives straight-line power from the beginning?

This is precisely what the British are doing right now. Their fantastic goal: a 200-m.p.h. train with no drive wheels and no moving parts to wear out or make noise.

In a cluttered laboratory at Manchester University I watched Dr. Eric Laithwaite, a 40-year-old electrical engineer with the build of a football tackle, climb into a weird cart.

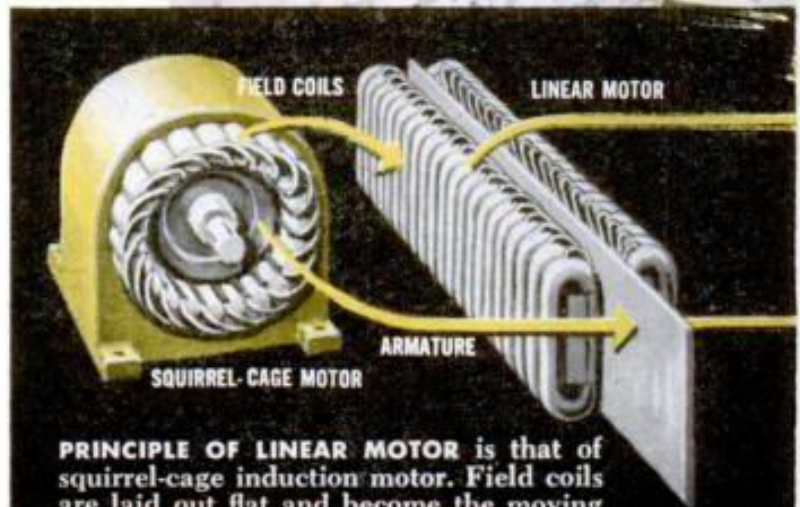
All about-r-r-d! He snapped a switch. Like a stone from a slingshot, he flashed down an 80-foot aluminum strip. The only sound was the swish of air. At the end of his run, Laithwaite grinned at me, snapped the switch again, and sped silently backward as swiftly as he had gone.

"This accelerates from rest to 25 m.p.h. in one second flat," he told me, straightening his broad shoulders. "It's like being clouted on the back with a heavy plank!"

Laithwaite's cart could be the crude forerunner of the 200-m.p.h. locomotive of the future. It pulls itself electromag-



"LEVAPADS" SLIDE
TRAIN ON
FILM OF AIR



PRINCIPLE OF LINEAR MOTOR is that of squirrel-cage induction motor. Field coils are laid out flat and become the moving element. An aluminum strip fixed to the roadbed plays the role of the armature. A moving magnetic field created by three-phase A.C. in coils induces circulating current in strip. This interacts with magnetic field to produce driving force.



THREE-PHASE
AC POWER

PANTOGRAPH

HS DENISON, 80-ton hydrofoil test ship, will skim ocean this summer at 60 knots. If fitted as passenger vessel, for coming trial in commercial service, she can carry 80 in airplane-type seats as in cutaway drawing at right.



The U. S. is launching

MIGHTY ENGINE of Denison, this 20,000-hp. gas turbine just completed for her by General Electric packs tremendous power in compact and lightweight 6,600-pound machine. Drive shaft will pierce big exhaust duct at left, as in drawing of ship.

By Alden P. Armagnac

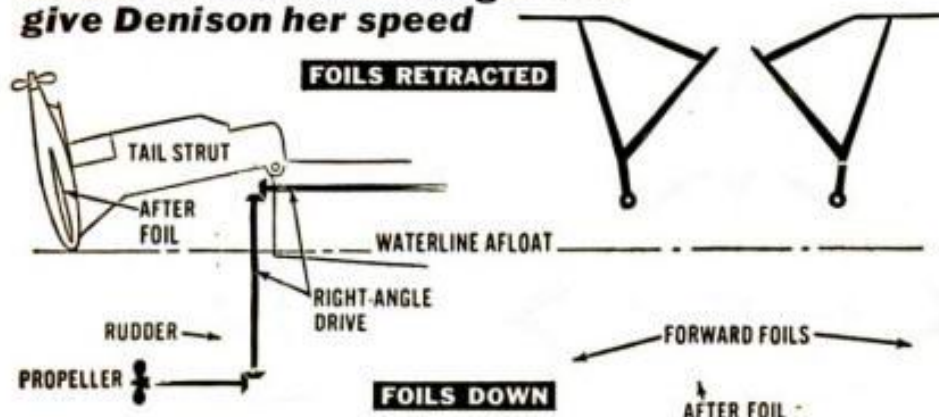
TWO new U. S. vessels with underwater wings may mark the greatest advance in marine design since steam replaced sail. The world's first hydrofoil ships designed for the high seas, they will inaugurate ocean travel at speeds up to 60 knots, or 70 m.p.h.

This summer will see the completion of

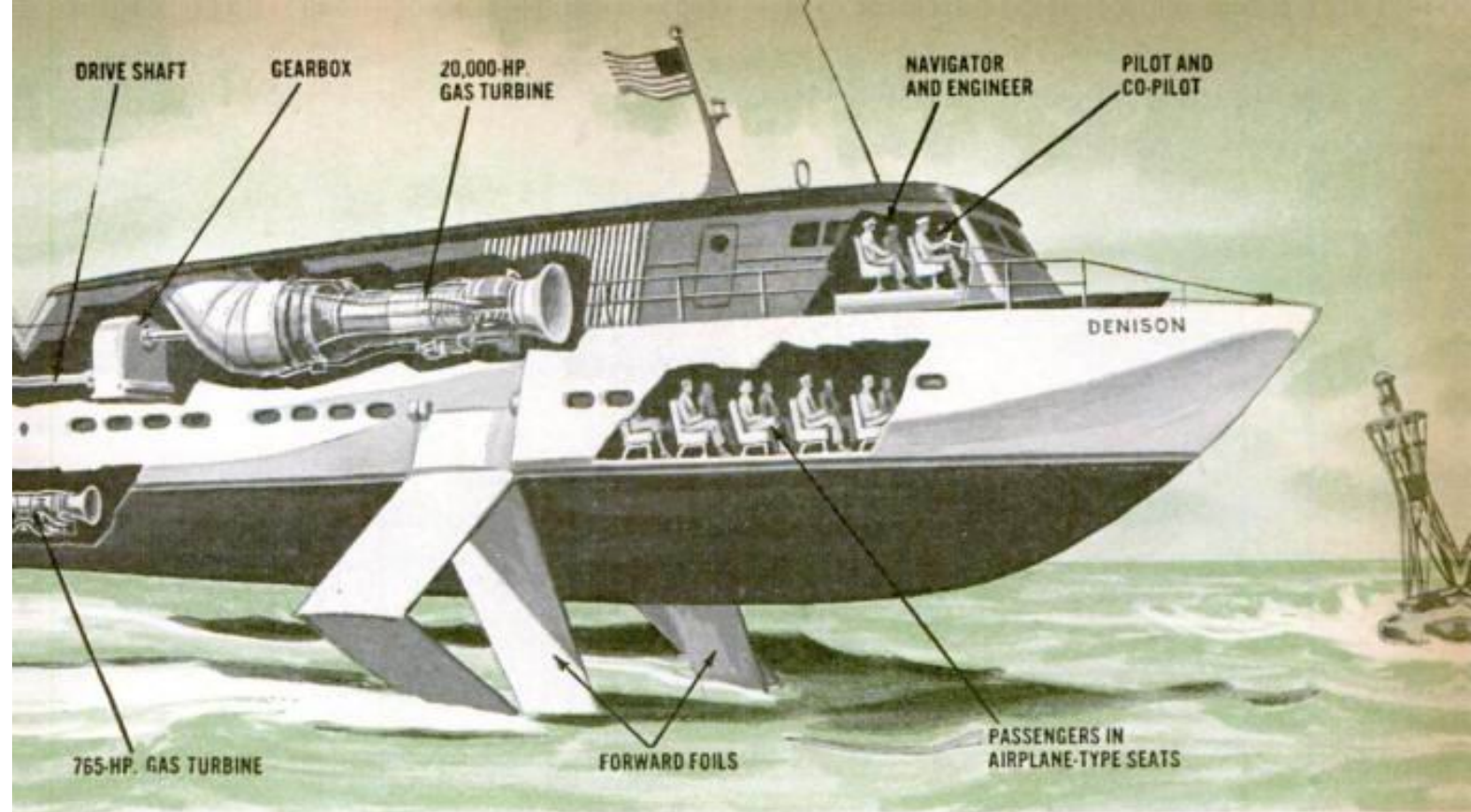
the HS (Hydrofoil Ship) Denison for the Maritime Administration at an Oyster Bay, N. Y., shipyard. Its 80-ton size ties the record for foilborne vessels, and it will be the first ocean-going one. And the keel has been laid for the biggest hydrofoil ever built—the seagoing 110-ton sub-chaser PC(H)-1, due to join the Navy next year.

Hydrofoil craft like these will bridge

These underwater "wings" will give Denison her speed



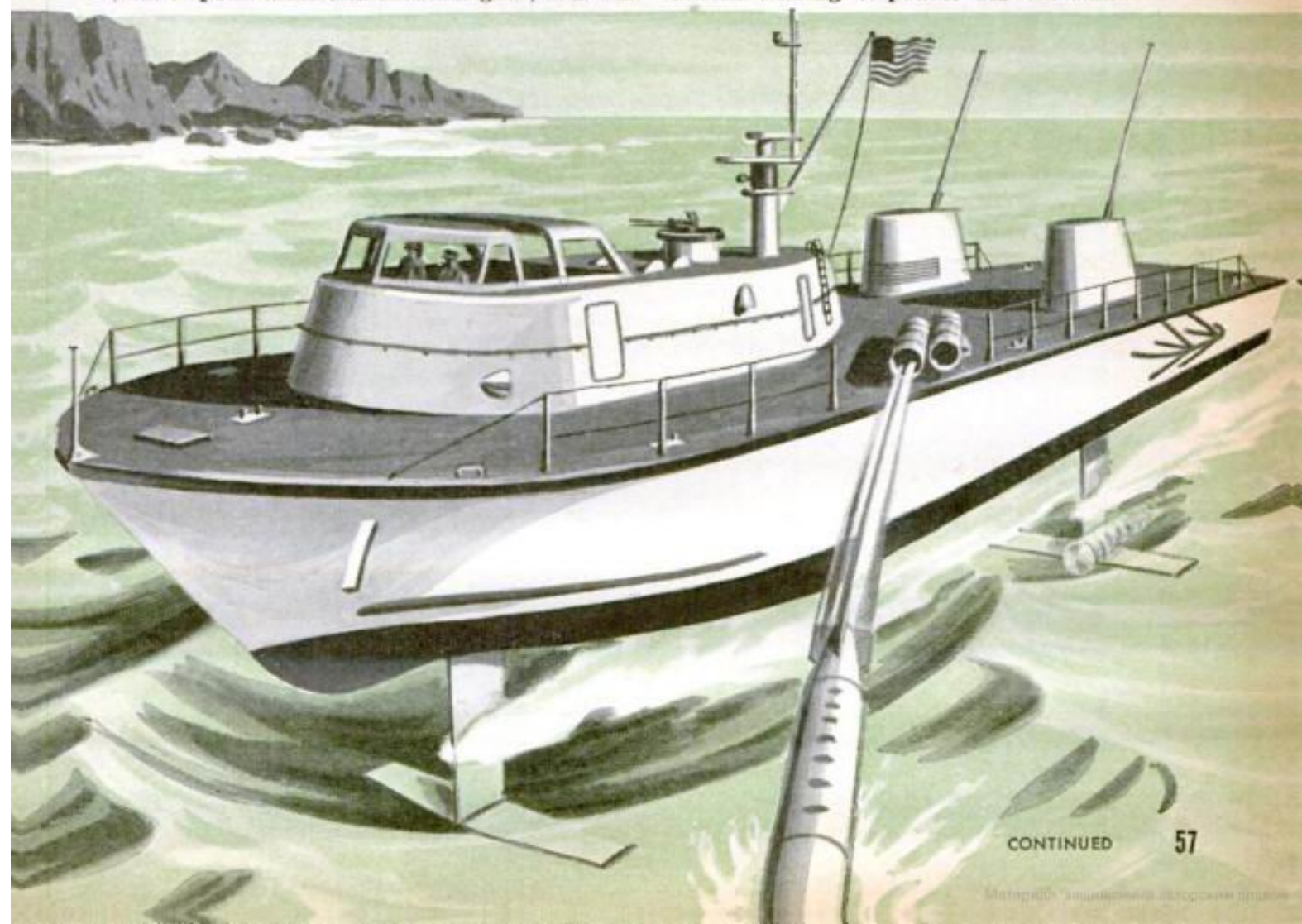
SHIP "FLIES" five feet above water on surface-piercing foils forward (left), and submerged foil aft (far left) attached to pod that also carries propeller. Automatic controls operate trailing flaps on forward foils, and vary inclination of tail foil, to check heaving, pitching, and rolling in heavy sea. For docking, retractable foils are raised from water, as shown.



the world's first ocean vessels to speed on underwater wings

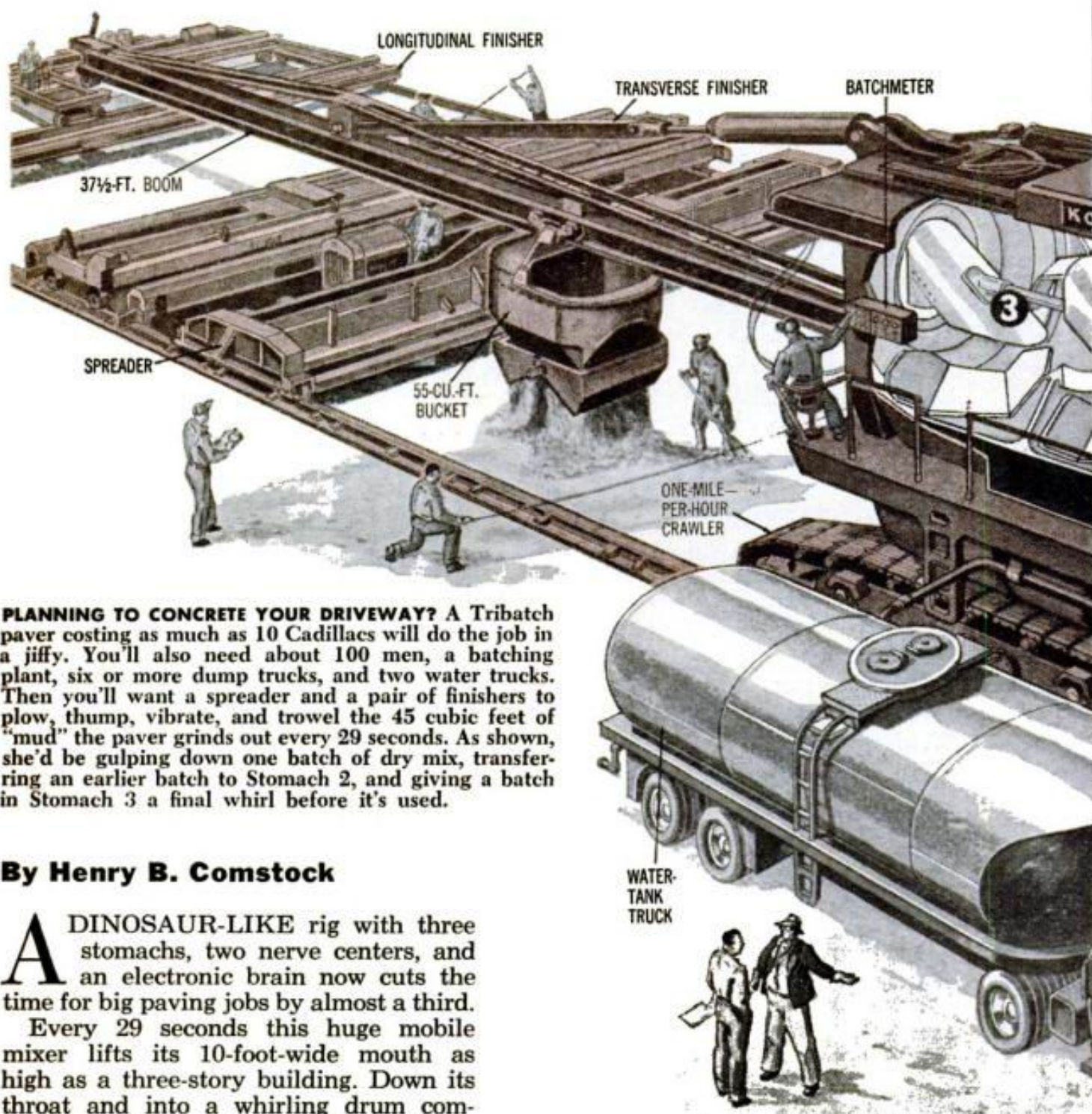
NAVY'S PC(H)-1, 110-ton subchaser due for completion next year, will be its first hydrofoil fighting ship. Combat-ready craft will be armed with torpedo tubes and machine guns, and will

have latest in sub-detecting sonar gear. At foil-borne speed of 40 to 50 knots, it will dash to location of a detected enemy submarine, and launch homing torpedoes for the kill.



Biggest Concrete Paver

This monster with a 10-foot mouth swallows 80 cubic feet of mix a minute, digests it one-two-three, and spews it forth



PLANNING TO CONCRETE YOUR DRIVEWAY? A Tribatch paver costing as much as 10 Cadillacs will do the job in a jiffy. You'll also need about 100 men, a batching plant, six or more dump trucks, and two water trucks. Then you'll want a spreader and a pair of finishers to plow, thump, vibrate, and trowel the 45 cubic feet of "mud" the paver grinds out every 29 seconds. As shown, she'd be gulping down one batch of dry mix, transferring an earlier batch to Stomach 2, and giving a batch in Stomach 3 a final whirl before it's used.

By Henry B. Comstock

A DINOSAUR-LIKE rig with three stomachs, two nerve centers, and an electronic brain now cuts the time for big paving jobs by almost a third.

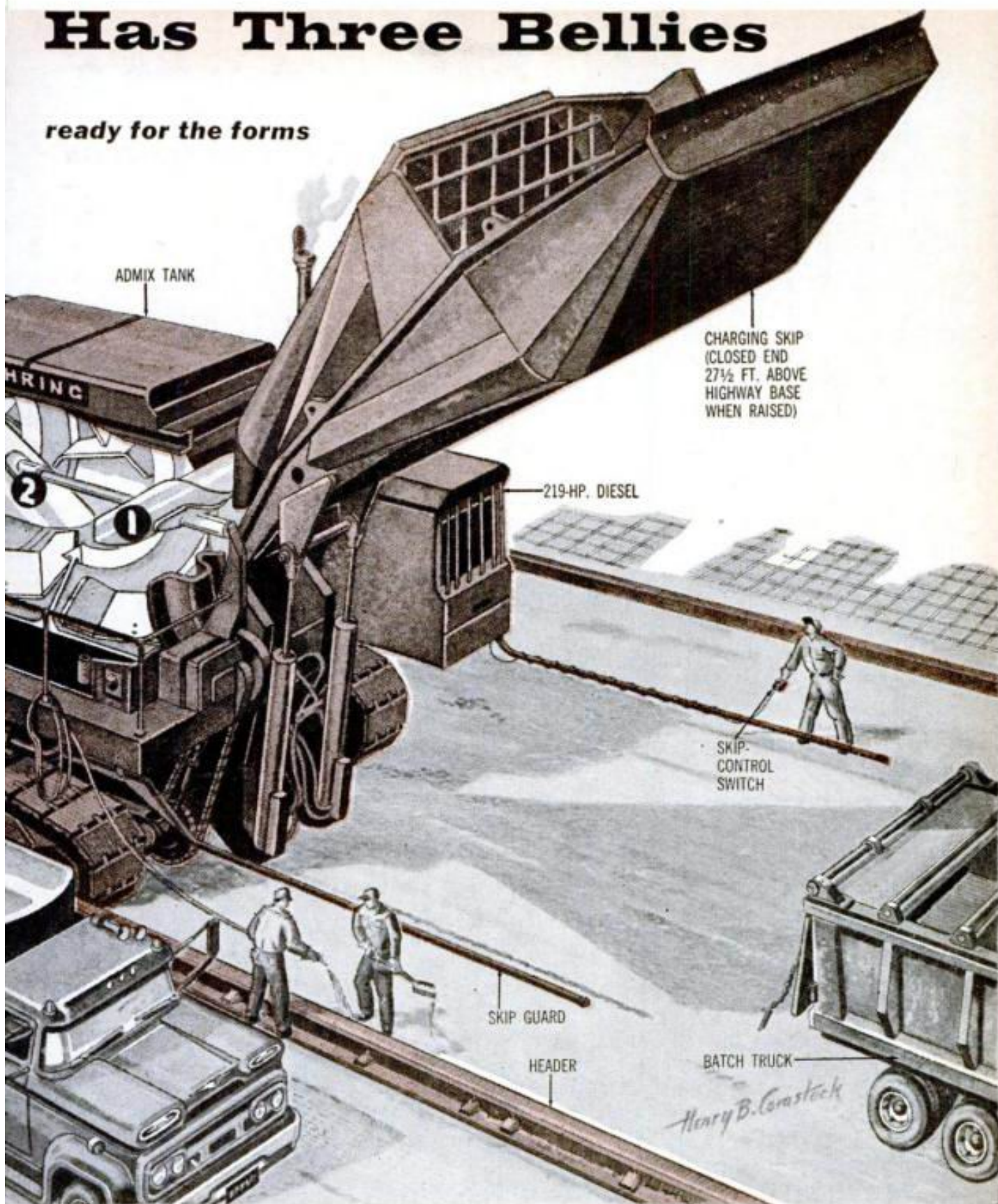
Every 29 seconds this huge mobile mixer lifts its 10-foot-wide mouth as high as a three-story building. Down its throat and into a whirling drum compartment rattles 40 cubic feet of dry gravel, sand, and cement. Simultaneously, an earlier batch, blended with just the right amount of water, tumbles into a second compartment. In still a third, a fully churned mix is ready for transfer to a boom bucket that will dump it between the forms, or "headers," of the

highway wending its way to the horizon.

It's this one-two-three routine that sets the new Koehring Tribatch mixer apart from all former machines. Shoving the batter along at the rate of 124 charges an hour, it whips up the makings of half

Has Three Bellies

ready for the forms



a mile of two-lane highway every work day.

An old trick made better. Upping performance by sending concrete through a mixer in lapping cycles isn't new. More than 30 years ago the Koehring Co., along

with other outfits, developed a dual-drum paver. That was a neat way around a problem common to manufacturers in many industries: You can't always make a good rig better simply by building it bigger.

CONTINUED

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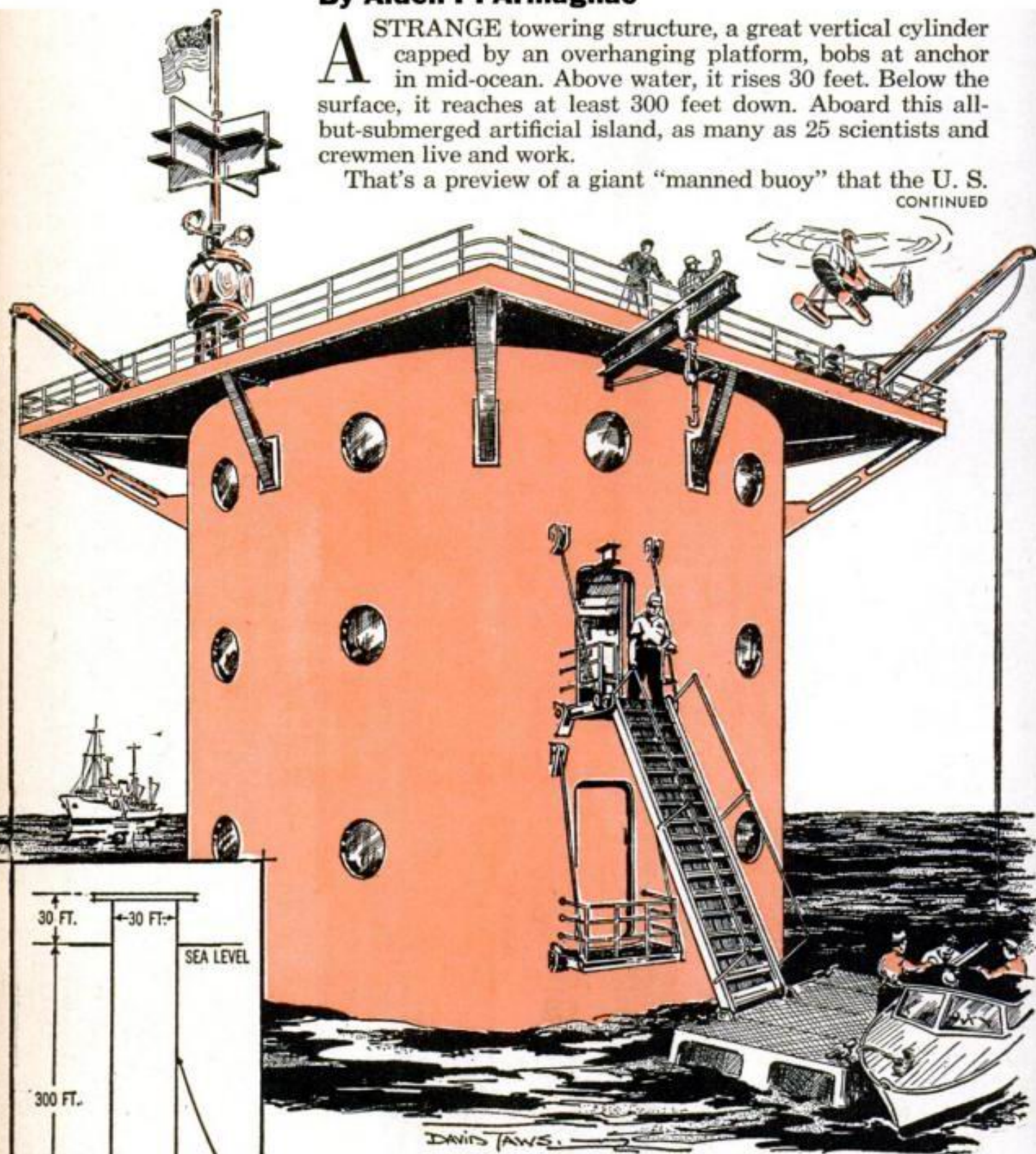
Manned Buoy to Probe Ocean Depths

By Alden P. Armagnac

A STRANGE towering structure, a great vertical cylinder capped by an overhanging platform, bobs at anchor in mid-ocean. Above water, it rises 30 feet. Below the surface, it reaches at least 300 feet down. Aboard this all-but-submerged artificial island, as many as 25 scientists and crewmen live and work.

That's a preview of a giant "manned buoy" that the U. S.

CONTINUED



ANCHORED IN MID-OCEAN, proposed manned buoy would serve scientists as a sea observatory. Silo-shaped structure, more than 300 feet tall, floats mostly submerged (inset) and more stably than a ship. Deck atop it provides helicopter port, beacon, and radar reflector.

**Inside view shows how observers
live and work aboard buoy**

OBSERVATION DECK
AND HELICOPTER PORT

RADIO CENTER
AND METEOR-
OLOGICAL STATION

GENERATING PLANT
to provide light
and power for buoy

ELECTRIC ELEVATOR
and stairs

SEA LEVEL

LIVING QUARTERS
for 10 to 15 scien-
tists and operating
crew of 5 to 10

LABORATORIES
for studying biological
specimens, analyzing
samples of sea water,
and other research

OBSERVATION GALLERY
for viewing subsea life

MACHINE SHOP
AND PHOTO LAB

STORAGE
for provisions and
laboratory supplies

BALLAST
and buoyancy tanks,
flooded to up-end buoy
after it has been towed
horizontally to site

BEACON
LIGHT

GEAR FOR
LOWERING
INSTRUMENTS
INTO SEA

LANDING
STAGE

(MORE LABS,
OBSERVATION
GALLERIES,
SHOPS, AND
STOREROOMS
IN SECTION
NOT SHOWN)

UNDERSEA
LAMPS ON
EXTERIOR
OF BUOY

DAVID TAYLOR

Biggest Solar Telescope to Spy Out Sun's Secrets

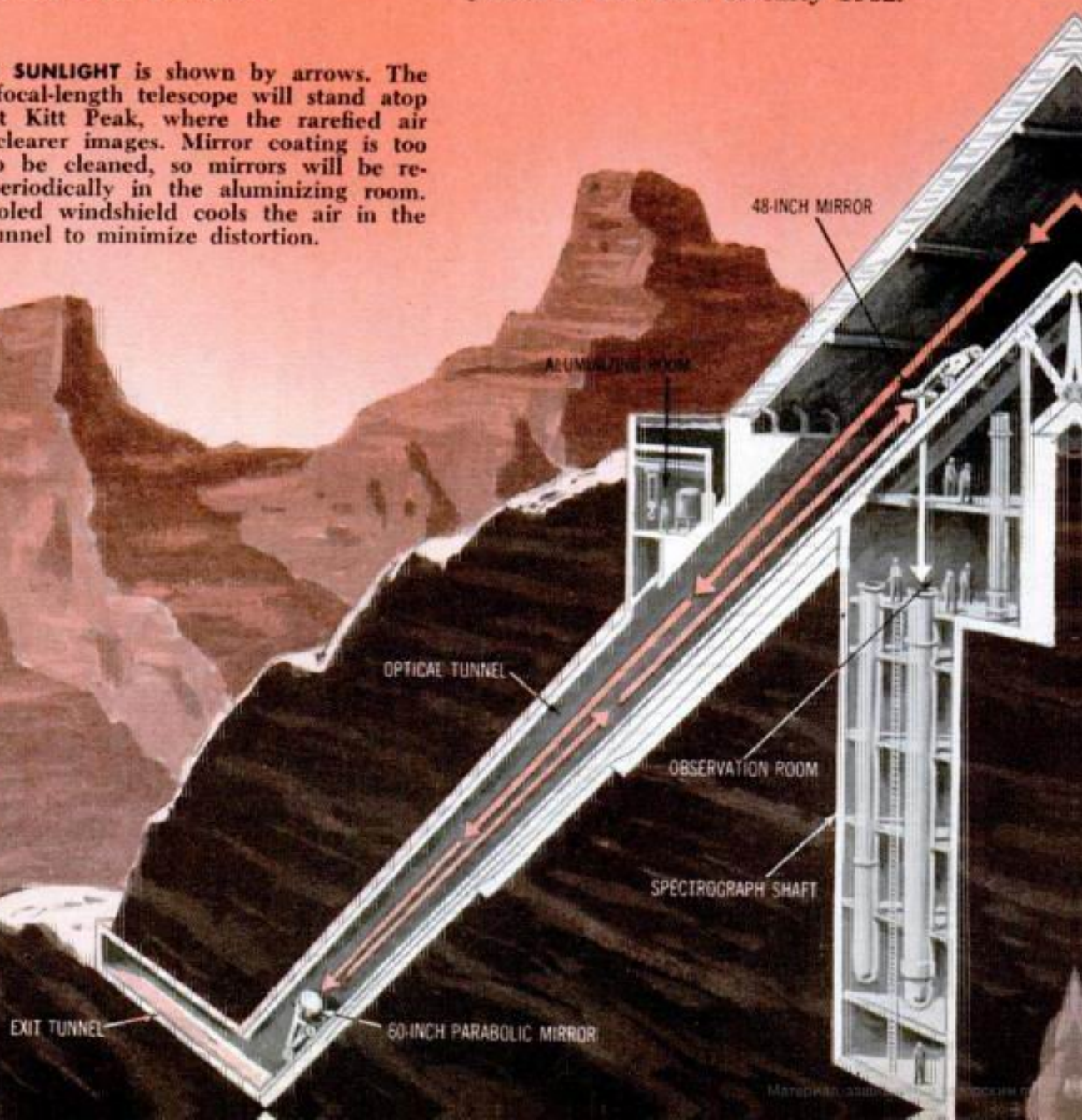
WHAT causes the violent eruptions of flaming gases on the sun's surface? Why are sunspots often accompanied by magnetic storms on earth? What is the nature of the corona, the strangely luminous outermost layer of the sun's atmosphere?

Soon these and many other questions about the star that keeps our planet alive may be answered by the world's largest solar telescope, now under construction at Kitt Peak National Observatory, near Tucson, Ariz. The giant instrument will provide sun images up to 34 inches in diameter, many times larger than those of any other solar telescope.

It will transmit the images via three front-coated mirrors. The primary mirror, an 80-inch flat heliostat, will be tilted by clockwork to reflect sunlight constantly down a 480-foot optical shaft to a secondary mirror, a 60-inch parabolic unit. From here the image will be reflected back 280 feet and focused on a 48-inch flat mirror, whence it will be directed to an underground observation room. The image can then be photographed or shunted to spectroscopes, devices that divide light into its component parts.

The telescope is expected to be completed in late 1961 or early 1962.

PATH OF SUNLIGHT is shown by arrows. The 300-foot-focal-length telescope will stand atop 6,875-foot Kitt Peak, where the rarefied air permits clearer images. Mirror coating is too fragile to be cleaned, so mirrors will be re-coated periodically in the aluminizing room. Water-cooled windshield cools the air in the optical tunnel to minimize distortion.



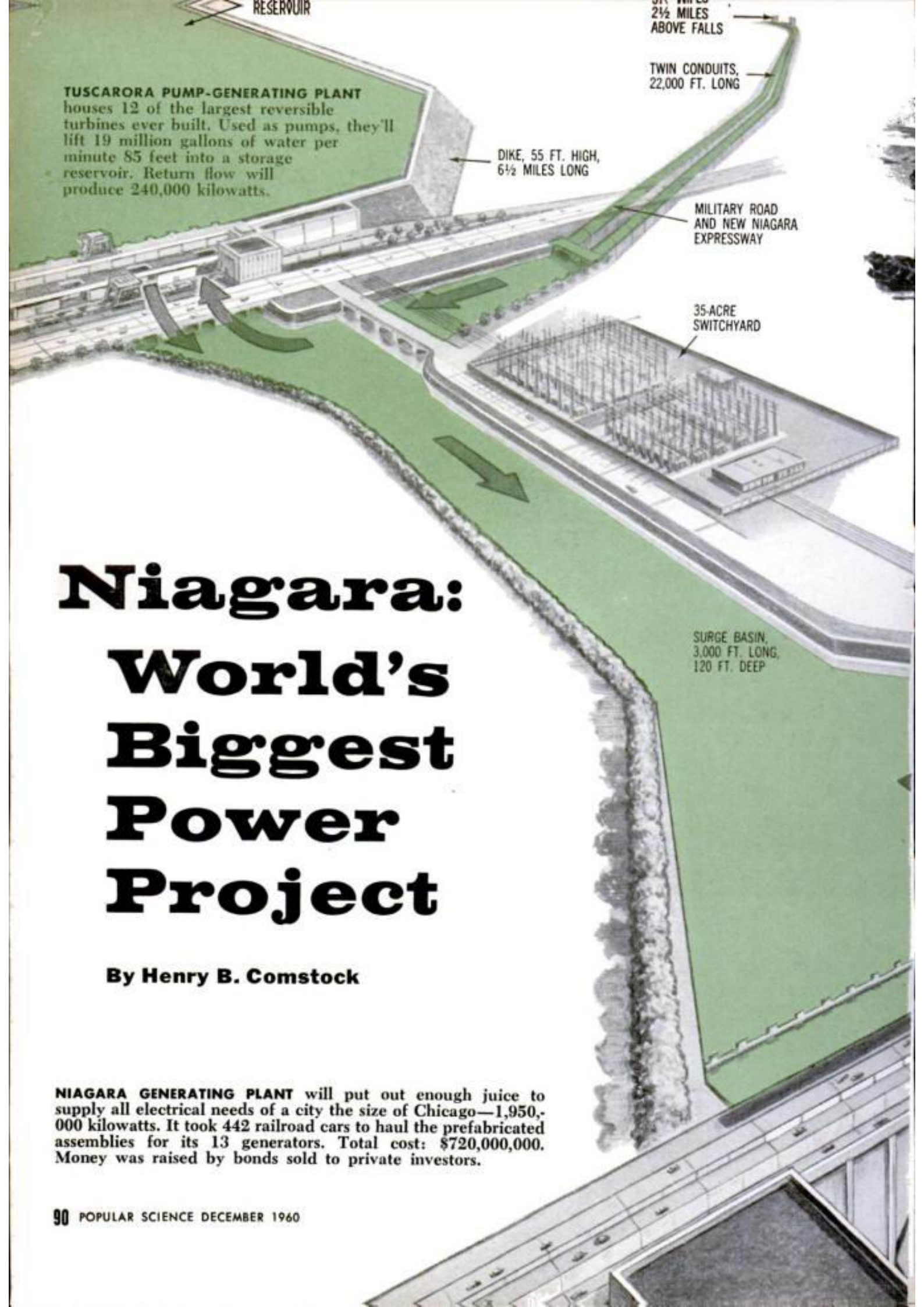


SUNLIGHT

80-INCH
HELIOSTAT

WATER-COOLED
WINDSHIELD

HELIOSTAT
SUPPORT TOWER



TUSCARORA PUMP-GENERATING PLANT houses 12 of the largest reversible turbines ever built. Used as pumps, they'll lift 19 million gallons of water per minute 85 feet into a storage reservoir. Return flow will produce 240,000 kilowatts.

5 1/2 MILES
2 1/2 MILES
ABOVE FALLS

TWIN CONDUITS,
22,000 FT. LONG

DIKE, 55 FT. HIGH,
6 1/2 MILES LONG

MILITARY ROAD
AND NEW NIAGARA
EXPRESSWAY

35-ACRE
SWITCHYARD

SURGE BASIN,
3,000 FT. LONG,
120 FT. DEEP

Niagara: World's Biggest Power Project

By Henry B. Comstock

NIAGARA GENERATING PLANT will put out enough juice to supply all electrical needs of a city the size of Chicago—1,950,000 kilowatts. It took 442 railroad cars to haul the prefabricated assemblies for its 13 generators. Total cost: \$720,000,000. Money was raised by bonds sold to private investors.



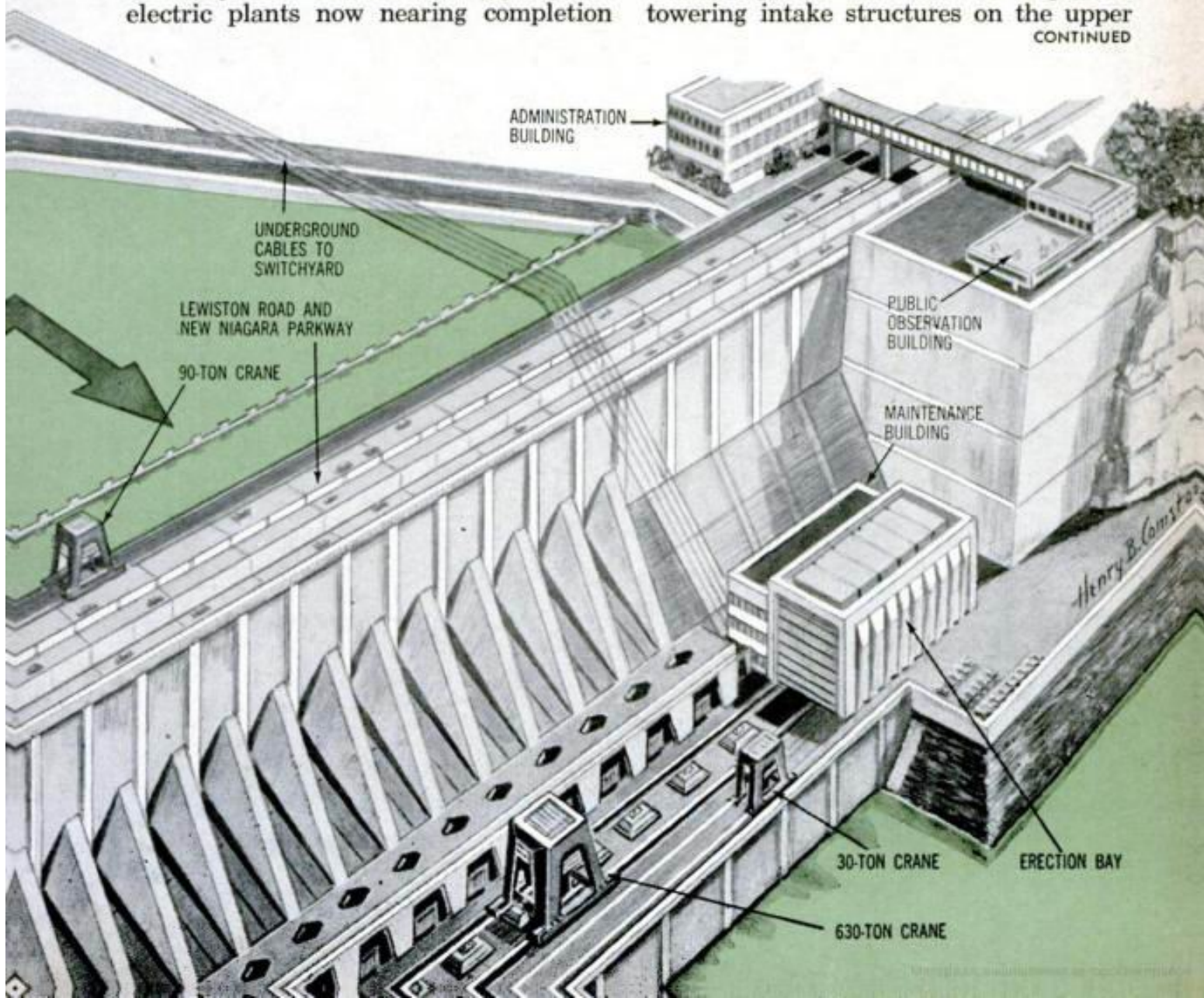
THE honeymoon is almost over for 24 million gallons of water a minute now crashing wastefully over Niagara Falls.

This loss of four million potential horsepower will end dramatically next February. At that time two huge hydro-electric plants now nearing completion

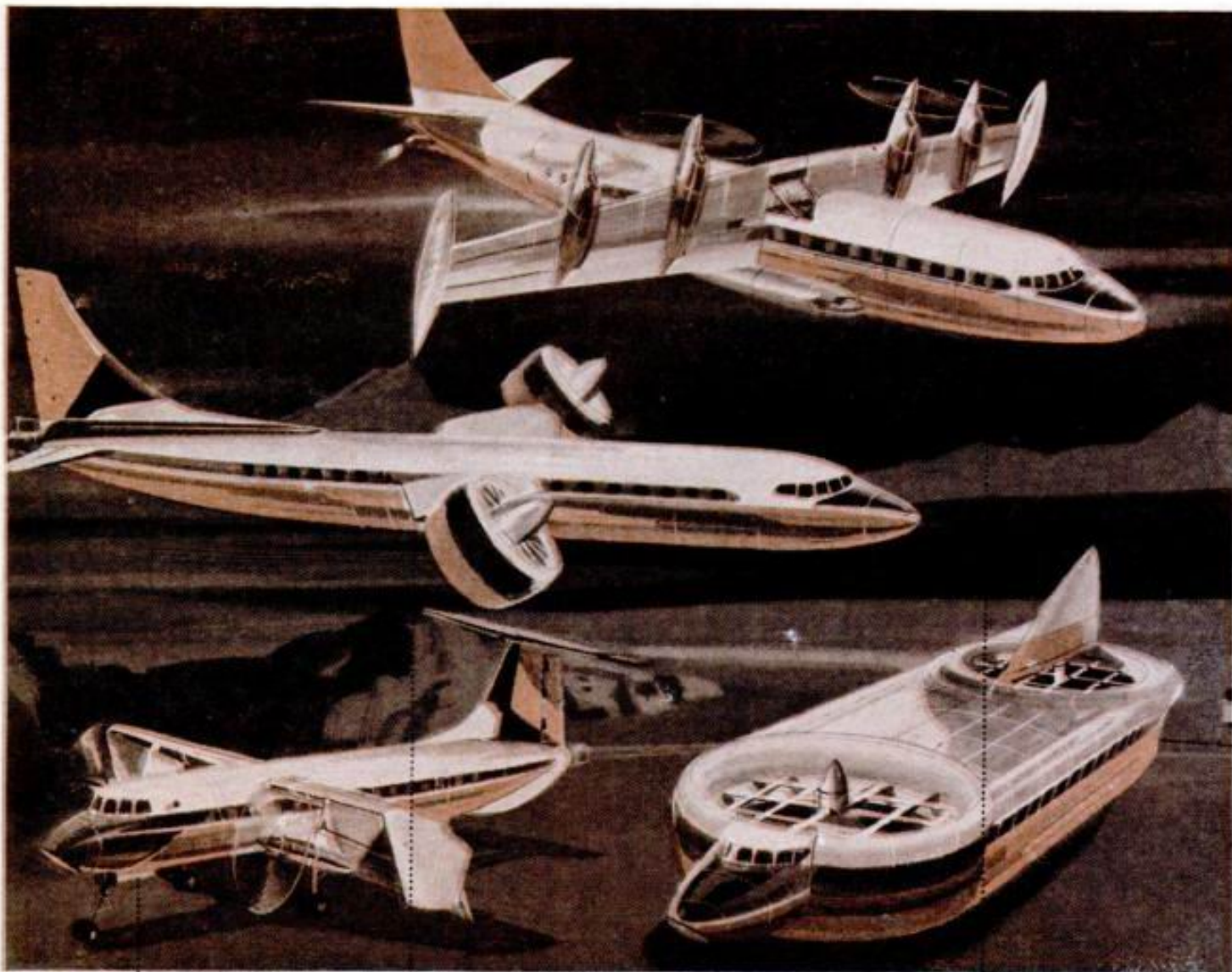
below the cataract will begin to create power. Together, they'll pour the greatest flow of kilowatts ever generated at a single power site into thousands of miles of transmission lines spiderwebbing the Niagara frontier.

The big show will start at a pair of towering intake structures on the upper

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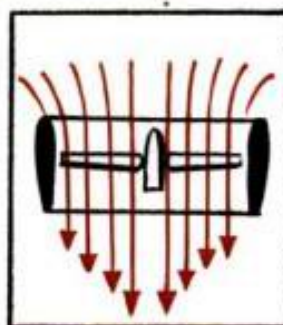
Airliners That Take Off from a Parking Lot



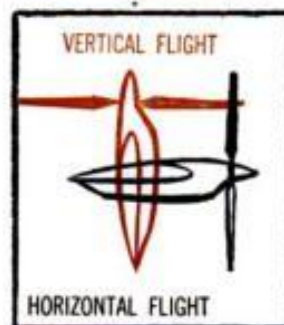
Ryan Vertiplane lowers flaps to bend air flow down (colored arrows), lifting plane straight up



Doak rotates the engines: blowing air down for vertical flight, then blowing air back for level flight



Piasecki Flying Jeep, low-flying, has louvers in fan ducts to guide air flow for maneuvering



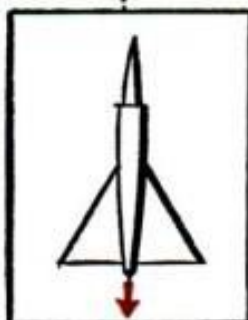
Hiller tilts wing and engines together to change from vertical to horizontal flight direction

Here come the VTOLs—planes that fly up and down like copters, forward like ordinary craft. They could lead to flying cars

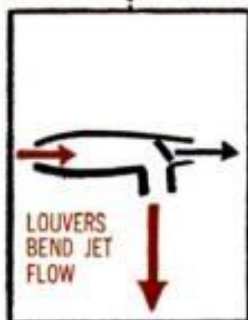
By Wesley S. Griswold

PLANES that behave like beefed-up helicopters seem certain to be flying into your life soon. None of them looks like a copter. Nor do they look quite like any airplane you know.

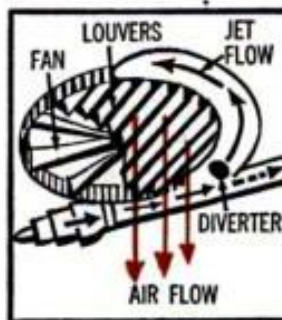
These curious new planes rise straight up from the ground, then fly normally, and return to earth straight down—gently, of course. They will also hover—stand still in mid-air. They are called VTOLs (pronounced Vee-tols), which stands for Vertical Takeoff and Landing.



Ryan Vertijet fighter takes off from its tail, noses over for level flight



Bell uses jet engine, deflects its thrust with louvers for vertical flight



Ryan-GE Vertifan will fly up on jet-driven fans, forward like ordinary jet plane. It is still in design stage. Small test versions of other VTOLs in drawing have already flown.

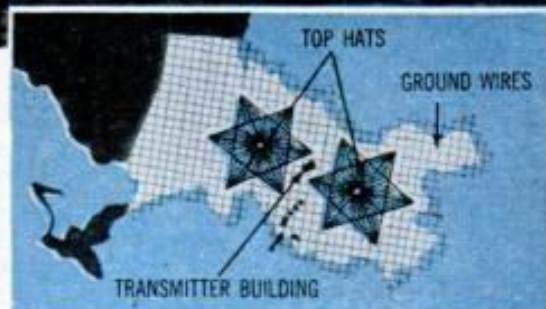
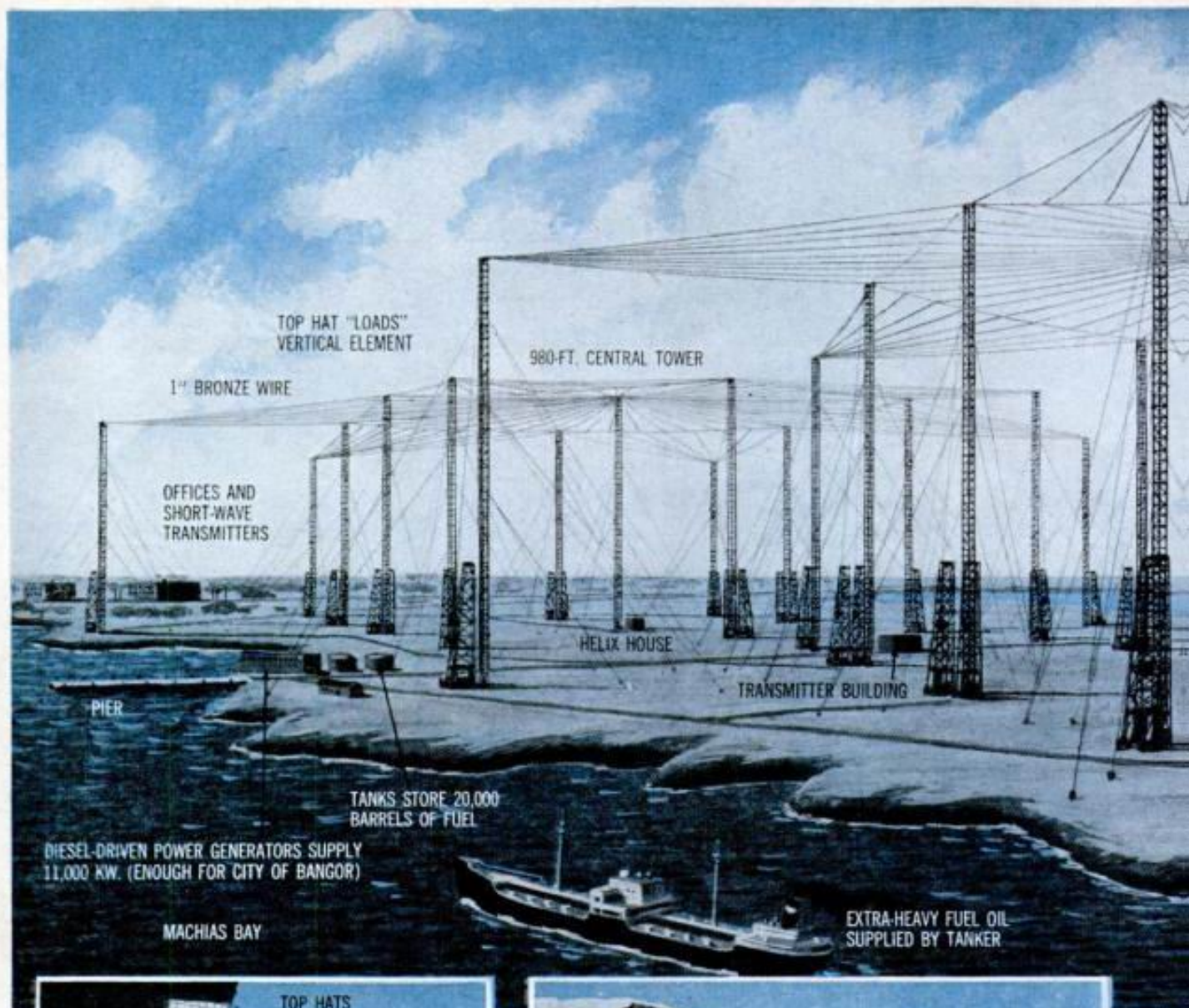


HORIZONTAL FLIGHT



Vertol tilts both wing and engines (like Hiller) to change direction

CONTINUED



STAR-SHAPED TOP HAT for each antenna covers area big enough for 11 Pentagons.

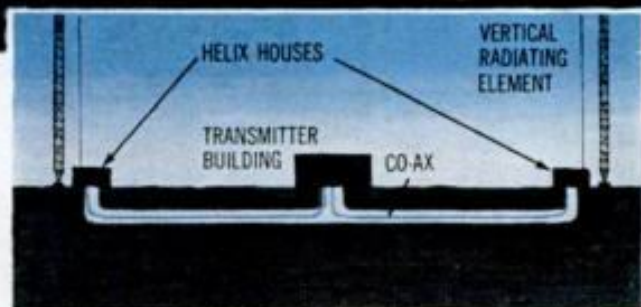
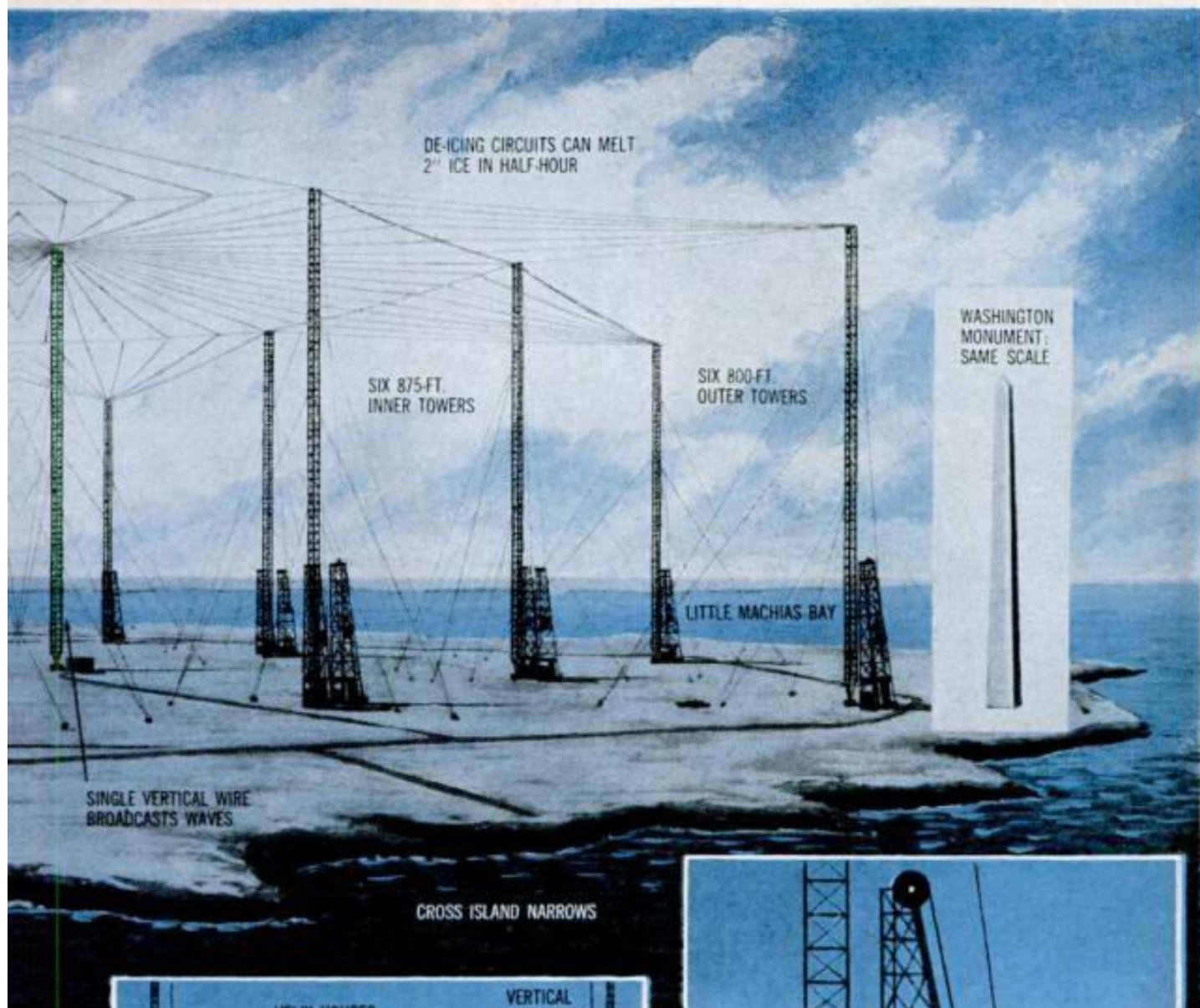


BURIED COPPER NET—electrical ground for antennas —underlies most of peninsula, trails off into sea.



SKINNY AND TALL, towers soar as high as 980 feet.

Navy Builds World's Most Powerful Transmitter

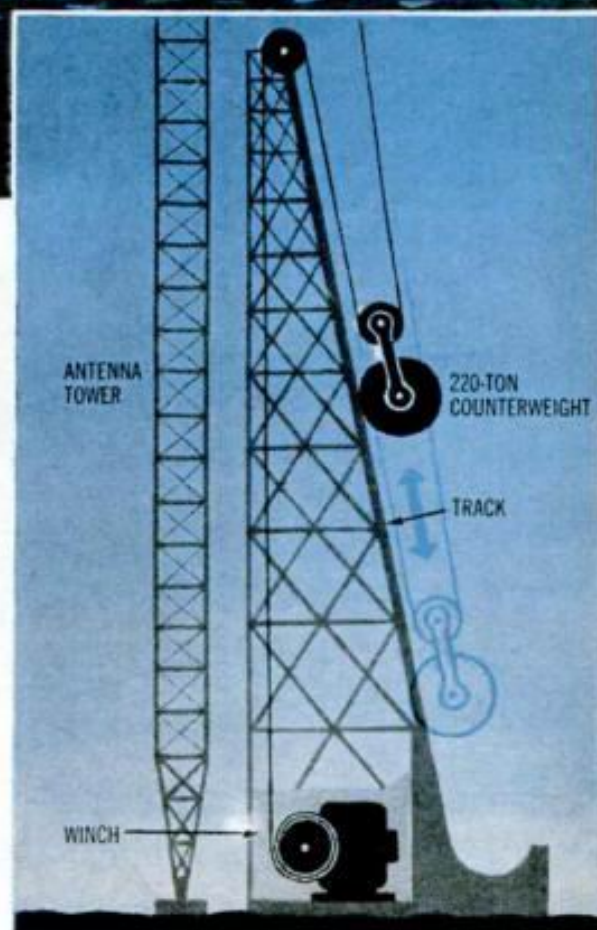


TUNNELS A MAN CAN WALK THROUGH hold huge co-ax feeding transmitter output to antennas.

A 2,000,000-watt radio station will achieve the "impossible": signaling U.S. subs underwater

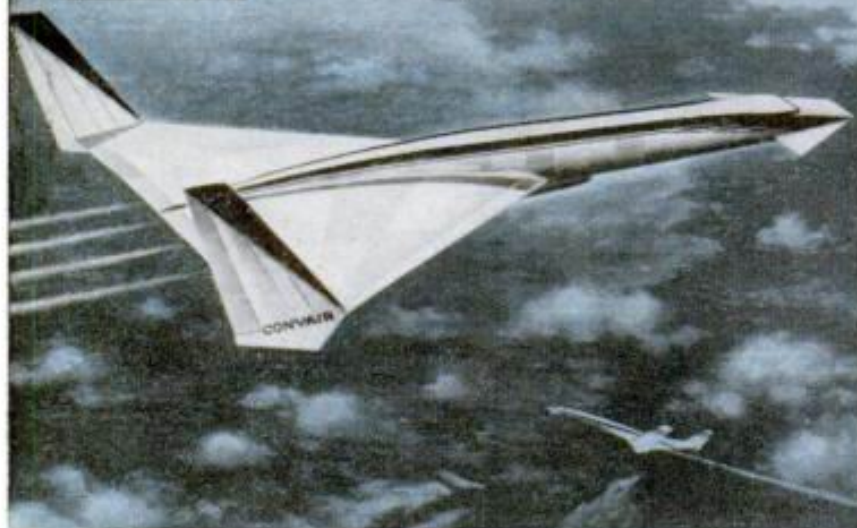
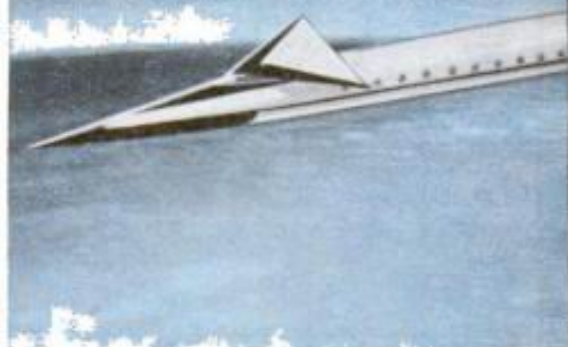
By Martin Mann

A FANTASTIC spider web covers an entire peninsula at the easternmost tip of Maine—715 acres of bronze lace 800 feet and more above ground. This is the antenna for the most powerful radio broadcasting station ever built.



COUNTERWEIGHTS, riding track, keep antenna cables aloft, compensate for sway in wind.

CONTINUED

CONVAIR**LOCKHEED**

One of these designs by three leading U.S. aircraft builders may be the shape of supersonic

Tomorrow's jetliners, cruising at 2,000 m.p.h., will streak—

Coast to Coast in 80 Minutes

By Eliot Tozer

IF YOU have ever watched the F-106 Delta Dart shoot straight up, like an arrowhead on a shaft of exhaust flame, you know how tomorrow's airliner will get up and go. Long, lean, and finned with knife-point wings, the new supersonic airliner will blast off almost like a missile.

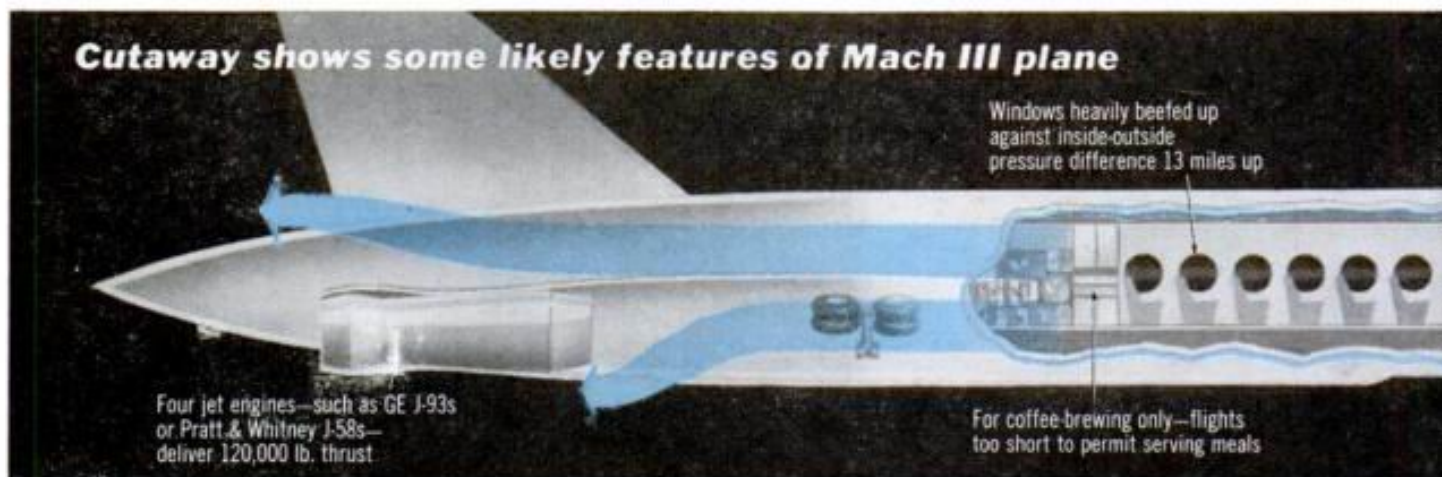
Commanding 120,000 pounds of thrust, it will climb to 38,000 feet at a no-sonic-boom 350 m.p.h., level off briefly, then really start climbing—at 600 m.p.h. At

cruising altitude, 70,000 feet, it will settle down to business at a glowing 2,000 m.p.h. Short minutes later, if it's on a coast-to-coast hop, it will dagger downward at 350 m.p.h.

Time from New York to Los Angeles: 80 minutes.

It's true that no such bird exists today. There probably won't be one ready to fly before 1963. And FAA approval may take another two years. But the supersonic airliner is far more than a doodle on a designer's scratch-pad. Lockheed has been holding skull sessions with U. S.

Cutaway shows some likely features of Mach III plane

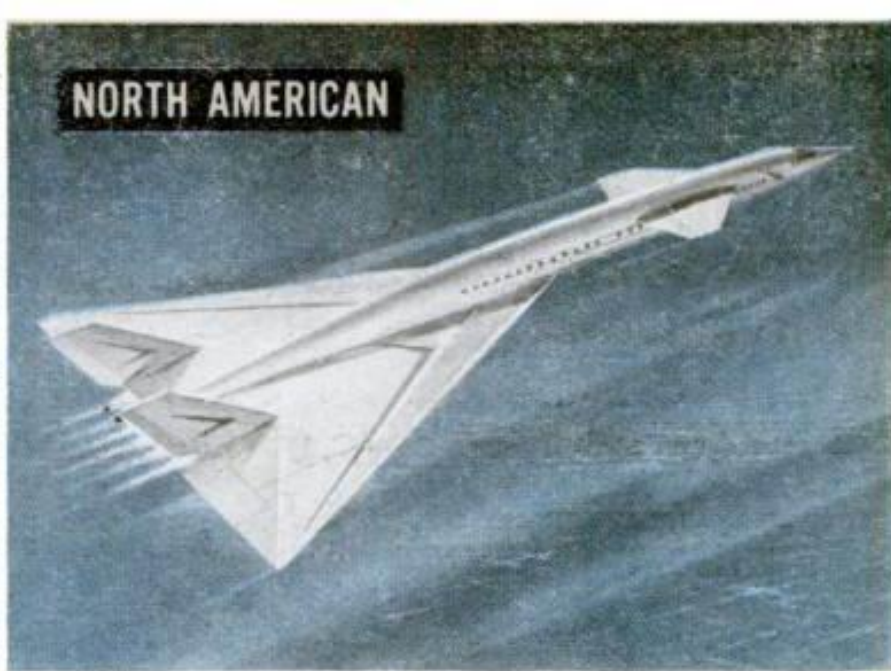
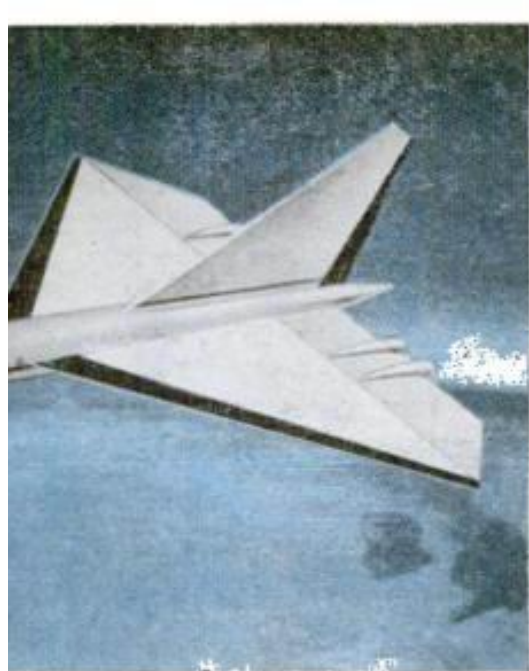


Windows heavily beefed up against inside-outside pressure difference 13 miles up

Four jet engines—such as GE J-93s or Pratt & Whitney J-58s—deliver 120,000 lb. thrust

For coffee-brewing only—flights too short to permit serving meals

NORTH AMERICAN



airliners to come—in five years or less. World leadership in commercial aviation is the prize.

airlines for the past two years. North American, prime contractor on the supersonic B-70, has piled up 14,000 hours of Mach 3 (three times the speed of sound) wind-tunnel time. Convair is studying design limits of a supersonic plane and its automatic systems. The British Ministry of Aviation this spring awarded Mach 3 study contracts to Hawker Siddeley and Rolls-Royce. Russia is well into actual construction.

The big race—with world leadership in commercial aviation for the next several years as the prize—is thus already half run. Here, based on unclassified reports from Lockheed and North American, is how our entry is shaping up.

Basically, it's a missile with portholes: long and very slender with stubby dart wings well aft where the tail should be. Its tiny tail is forward, like the tails on the Rascal and Hound Dog missiles. It's

clean and lean as a whippet, all "go."

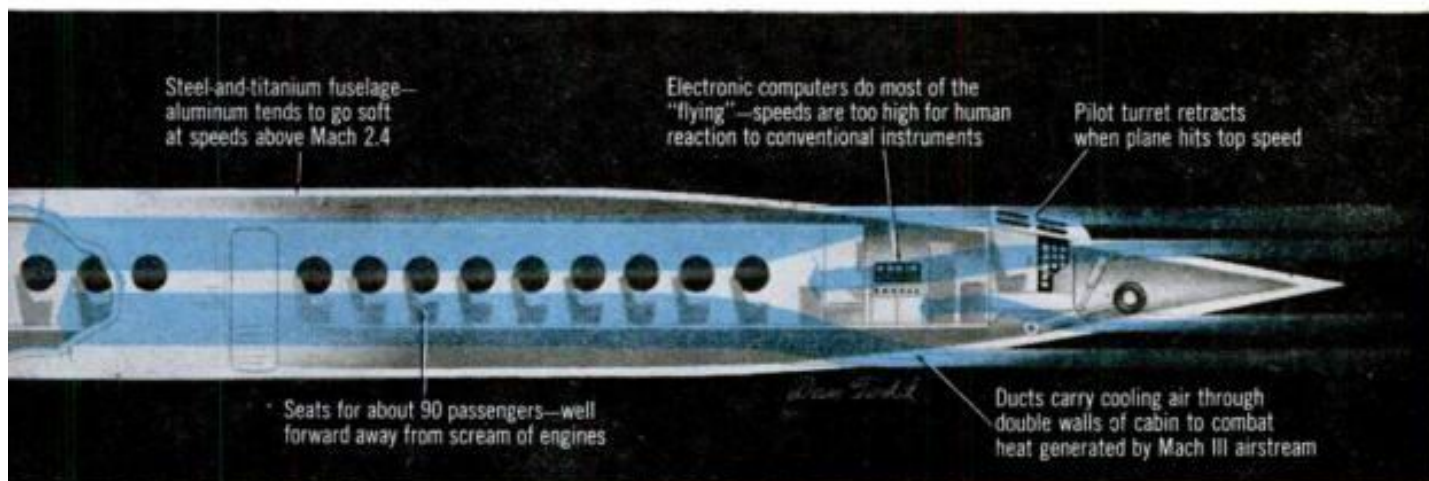
But even though it's a missile-with-men-in-it, it's a surprisingly simple machine—and a logical extension of today's subsonic jets rather than a breakthrough. In fact, the engineers are finding the supersonic airliner a kind of grab bag of surprises.

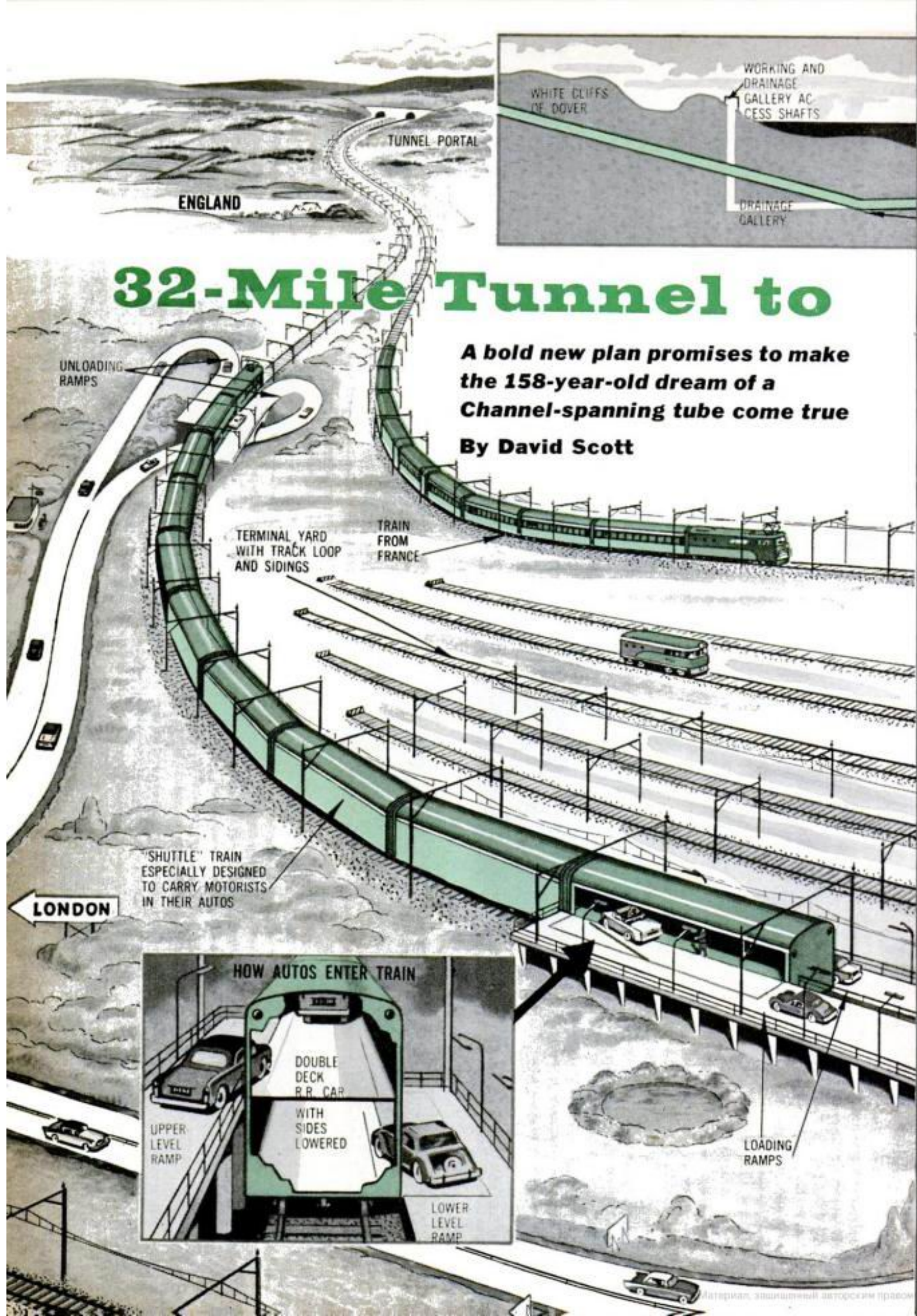
For example, it's not a giant, a sky hog. It is small and trim, smaller than any other jetliner. Probable number of passengers: 90, compared to the Boeing 707 Intercontinental's 170.

The reason is simple: Its incredible speed gives it three times the airlift of today's jets—so much airlift, in fact, that it would lift itself right out of the market if it got much bigger. Not many routes generate enough traffic to fill the equivalent of a 400-passenger airliner.

And it doesn't need eight, or even six

[Continued on page 190]





ENGLAND

TUNNEL PORTAL

WHITE CLIFFS OF DOVER

WORKING AND DRAINAGE GALLERY ACCESS SHAFTS

DRAINAGE GALLERY

32-Mile Tunnel to

A bold new plan promises to make the 158-year-old dream of a Channel-spanning tube come true

By David Scott

UNLOADING RAMPS

TERMINAL YARD WITH TRACK LOOP AND SIDINGS

TRAIN FROM FRANCE

"SHUTTLE" TRAIN ESPECIALLY DESIGNED TO CARRY MOTORISTS IN THEIR AUTOS

LONDON

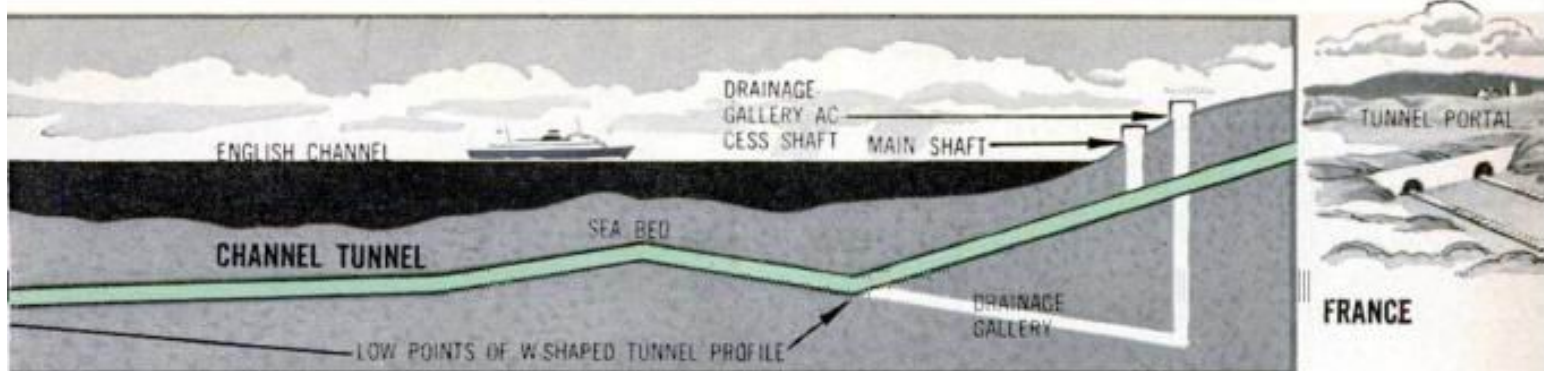
HOW AUTOS ENTER TRAIN

DOUBLE DECK R.R. CAR WITH SIDES LOWERED

UPPER LEVEL RAMP

LOWER LEVEL RAMP

LOADING RAMPS



Connect England and France

FROM a ramp, you drive right into a railway car at the rear of an electric train, standing at a terminal near Folkestone, England. You pilot your auto forward through the cavernous interior of the train—its cars are joined by platforms to make a continuous runway—and stop behind the next-earlier arrival. Other autos draw up behind you. Then the train starts, speeds nine miles above ground, and plunges into the most remarkable tunnel in the world.

Still sitting in your automobile, you are borne for 23 miles beneath the waters of the English Channel, at an average speed of 60 m.p.h. In less than 45 minutes, the train rolls to a stop. Motorists restart their engines, and you drive off the front of the train to find yourself in France. As you disembark at the French terminal near Calais, you see another line of autos about to board the

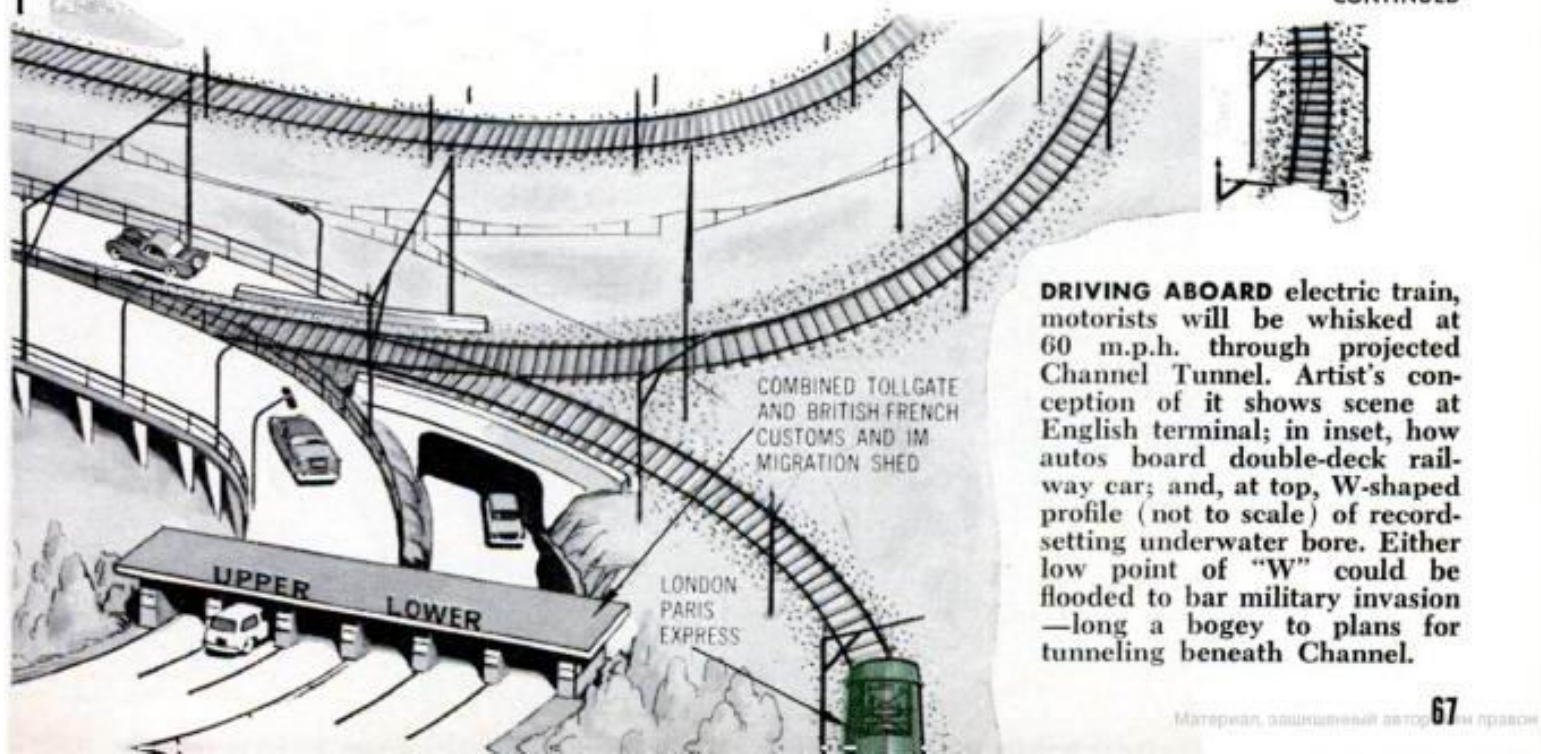
train for its return trip to England.

That is a preview of high-speed, all-weather, comfortable, and inexpensive travel between England and France by 1967, if a startling plan to drive a tunnel beneath the Channel goes through.

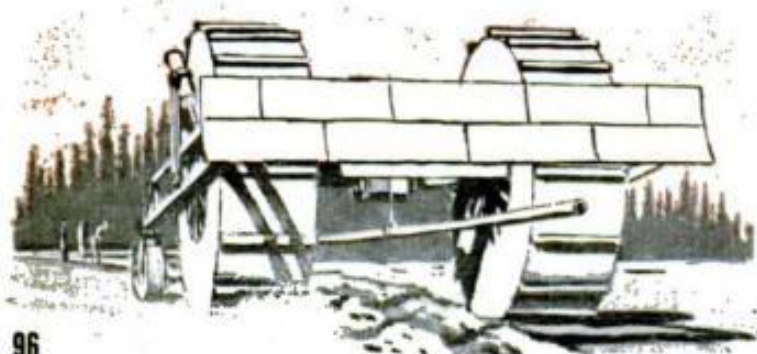
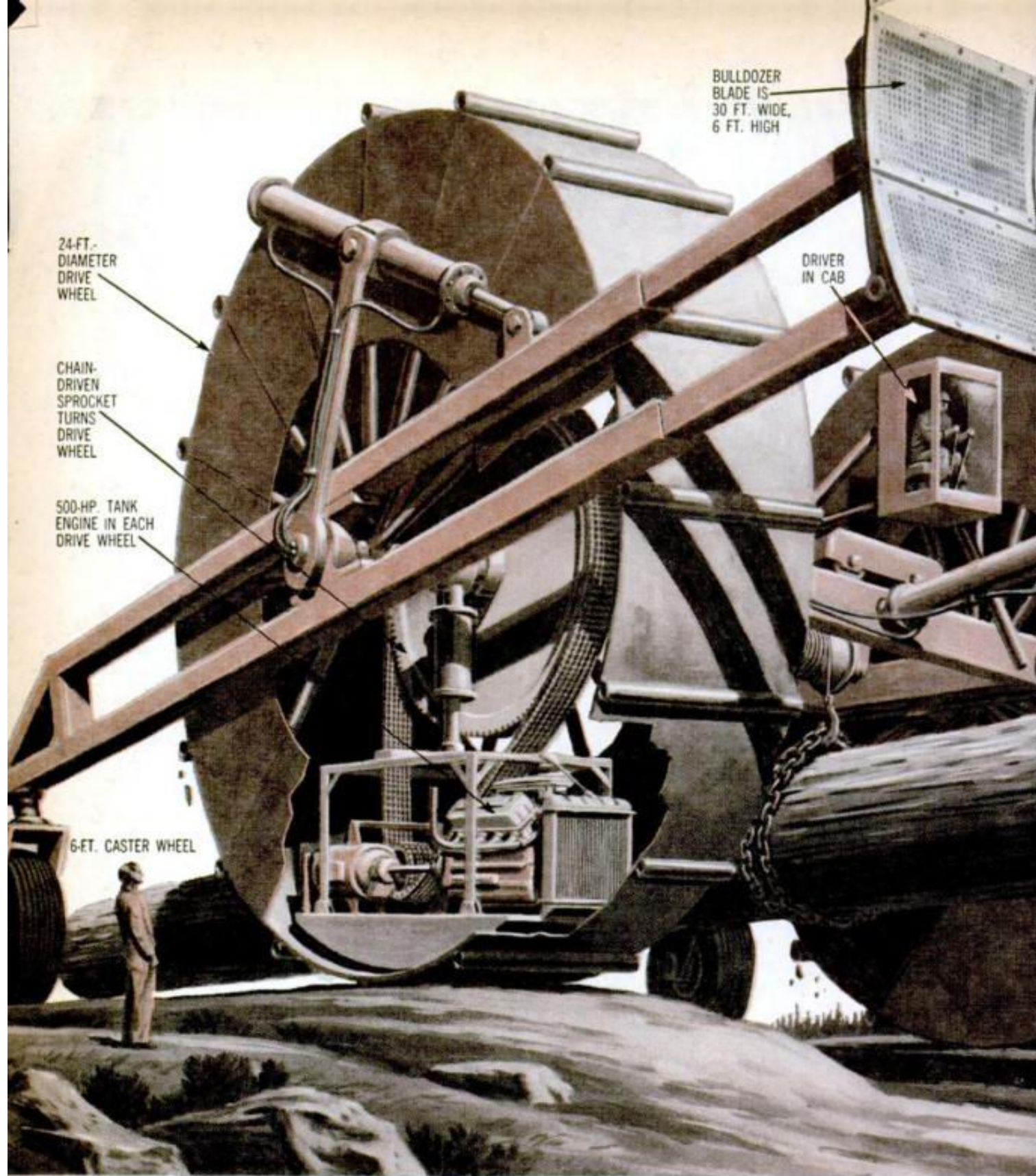
At 32 miles from portal to portal, it would be the world's longest passenger tunnel by so far as to be in a class by itself. It would dwarf the Alps' famed 12-mile Simplon rail tunnel, and the seven-mile vehicular tube under construction through Mont Blanc, the present and prospective record holders of their kinds. Its cost would exceed the \$300,000,000 value of the British crown jewels. Like the Great Pyramid of Egypt and the Panama Canal, the proposed Channel Tunnel would rank among the engineering wonders of all time.

Latest of many schemes to link Britain and France by tube or bridge, this mod-

CONTINUED



DRIVING ABOARD electric train, motorists will be whisked at 60 m.p.h. through projected Channel Tunnel. Artist's conception of it shows scene at English terminal; in inset, how autos board double-deck railway car; and, at top, W-shaped profile (not to scale) of record-setting underwater bore. Either low point of "W" could be flooded to bar military invasion—long a bogey to plans for tunneling beneath Channel.



AS TIMBER CARRIER, Bunyan Buggy can handle 120-ton load. Logs up to 40 feet long are suspended between wheels on chain from hoist.

AS A BULLDOZER, tractor wields 6-ton blade, 30 feet long and 6 feet high, which can push 96 cubic yards of earth at one shove.

Huge Logging Tractor Rolls on 24-Foot Wheels



TRACTOR CAN CARRY
40-FT. LOGS AND
TOTAL LOAD UP
TO 120 TONS

The fantastic 1,000-hp. Bunyan Buggy weighs 38 tons, hauls 120, stands as tall as a house

CITIZENS of the little town of Isleton, Calif., have been as full of curious expectancy these past few months as if one of their neighbors owned a pregnant elephant.

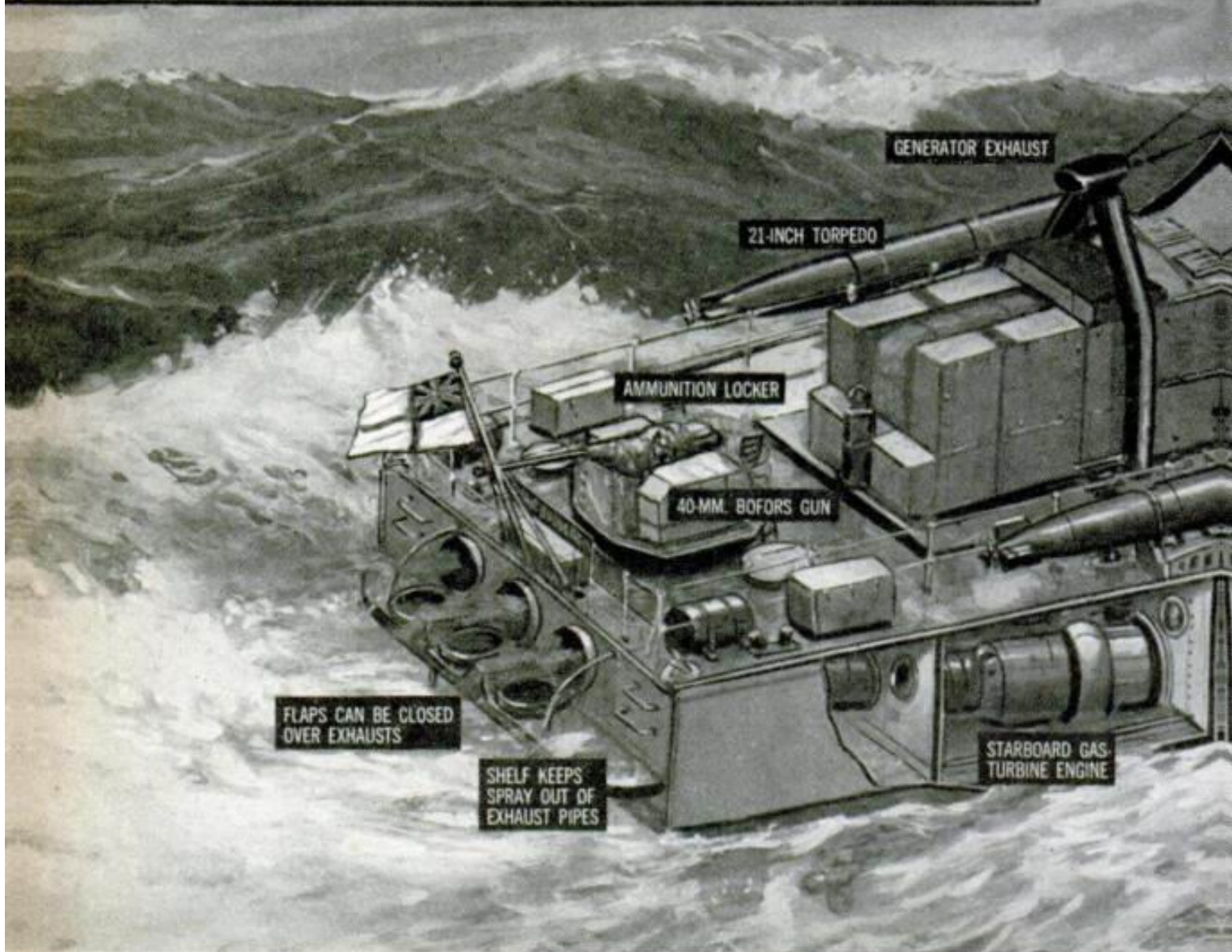
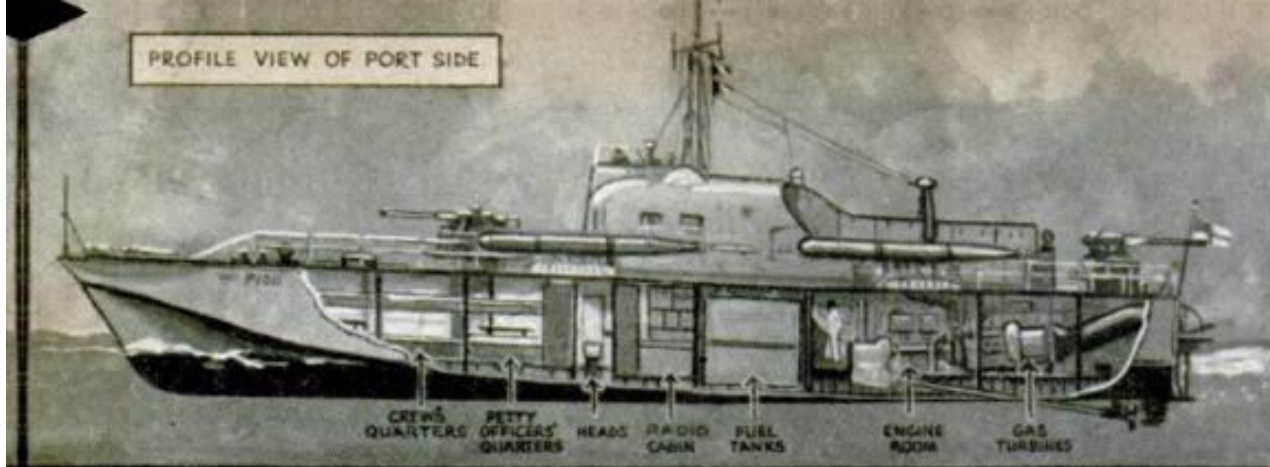
There was a widespread conviction in the community, crouched behind a levee by the muddy Sacramento River, that Something Big was sure to happen soon.

Their interest focused on a former cannery at the north end of the main street. Over its porch is nailed a broad sign that reads "Bunyan Buggy." Inside the old cannery, a fantastic vehicle of enormous size has been slowly taking shape. Just about everybody in town has dropped in from time to time to watch it grow.

Basically, the Buggy is a two-wheeled, self-propelled cart for hauling logs (meaning, in this instance, tree trunks up to 40 feet long). But what wheels it has! They are 24 feet in diameter—taller than many a two-story house—and five feet wide. They can cover a mile in only 70 turns. And those great, spoked wheels are designed to support payloads of as much as 120 tons, slung below the frame of the



PROFILE VIEW OF PORT SIDE

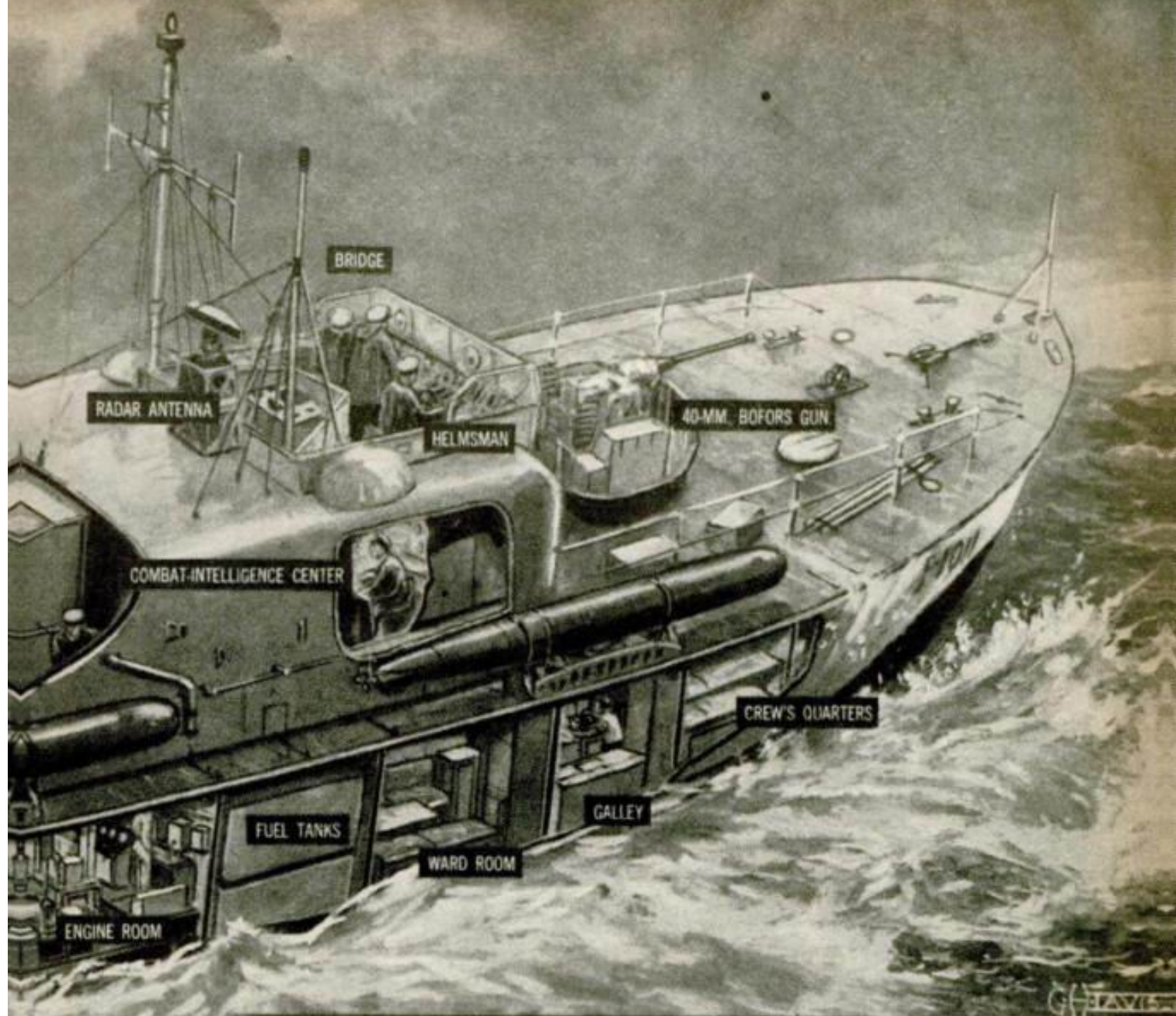


World's Fastest Fighting Vessel

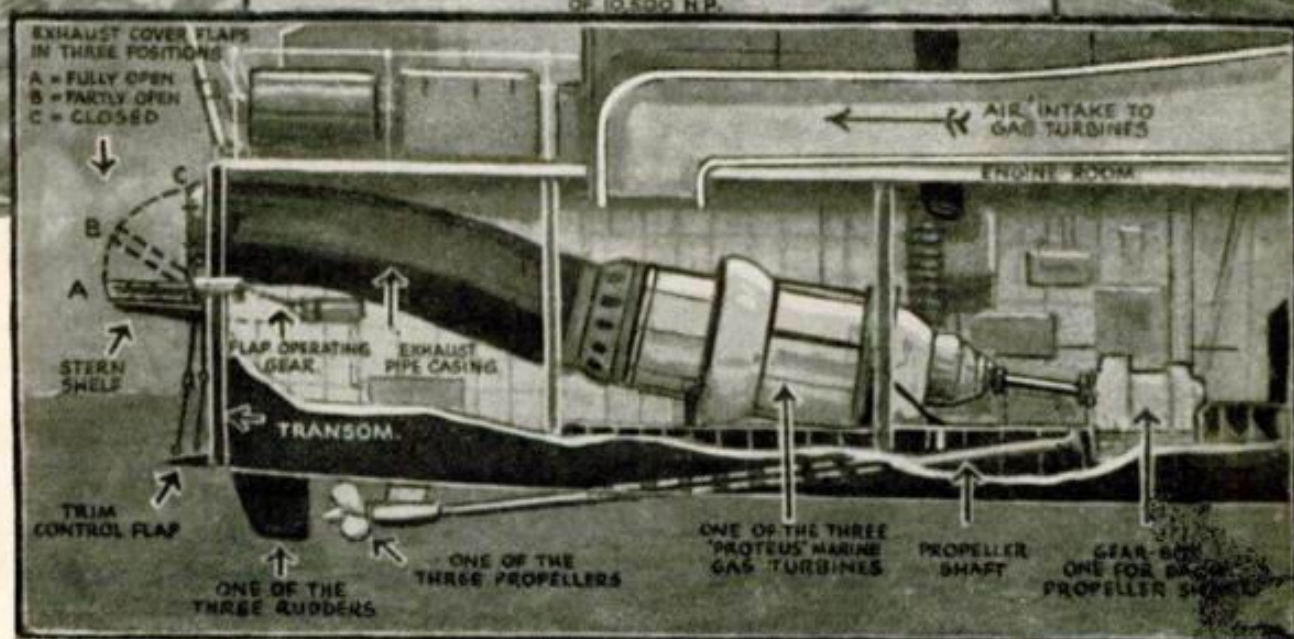
WITH three 2,800-hp. gas-turbine engines spinning its triple screws, HMS Brave Borderer accelerates from rest to 50 knots in only 30 seconds. First of a new class built for the British Admiralty by Vosper Ltd., the patrol craft can operate as a gunboat, torpedo boat, mine layer, or raider. It is believed to be the first warship with a service speed of over

50 knots, about 57 land miles an hour.

Displacing 100 tons when loaded, the vessel is 98.5 feet long, overall, and has a 25.5-foot beam. Hinged to the bottom of the transom is a unique trim flap controlled electro-hydraulically from the bridge. Lowering the flap points the boat's bow higher for greater speed or to reduce slamming in a heavy sea.



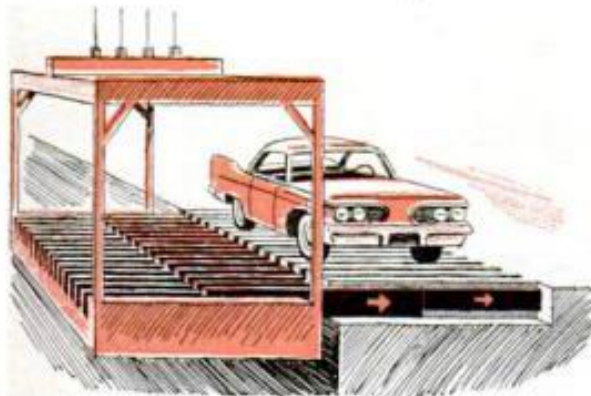
A DIAGRAM OF THE VEE-DRIVE WITH REVERSE GEAR-BOX AND THE PROTEUS MARINE GAS TURBINE INSTALLATION, WHICH DEVELOPS A TOTAL OF 10,500 N.P.



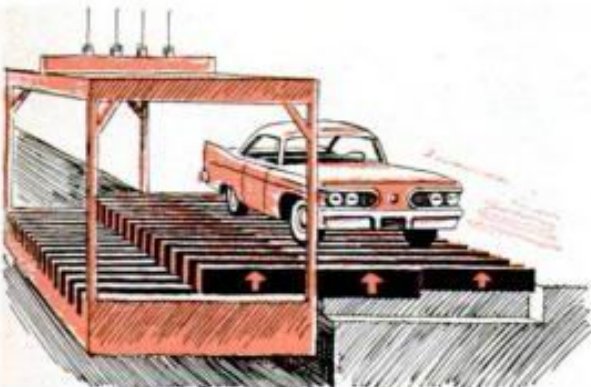
On the Way:

Parking problems? These devices swing and stack your car to get it out of your hair

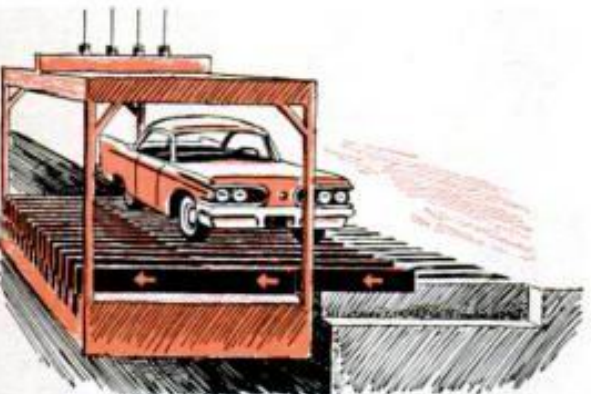
1 ENTERING, motorist drives car onto platform, is given key (his receipt) from control panel. Removing key starts machinery.



2 TWO-SECTION CONVEYOR GRID in elevator is activated when key is removed. Opening, it slides between platform grids.



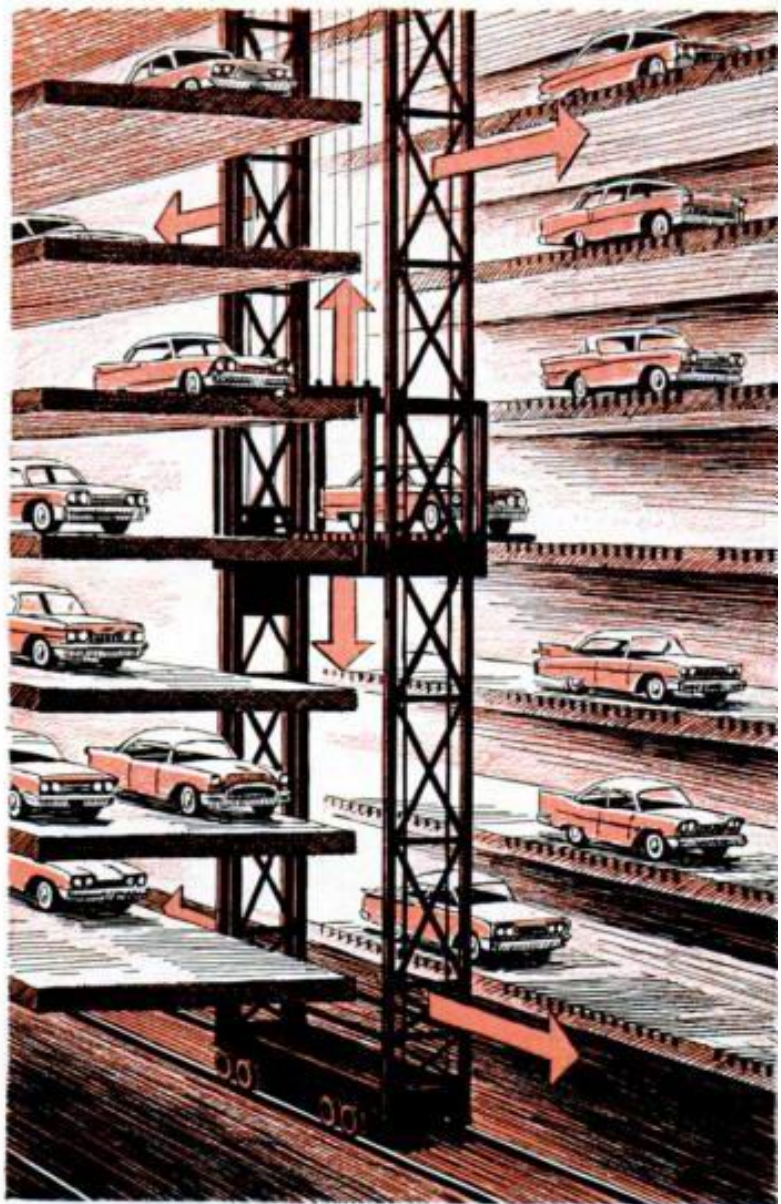
3 RISING at end of sideward movement, conveyor lifts car up off its platform.



4 SLIDING BACK, conveyor takes car into elevator. Elevator will then rise—as its wheeled tower rolls sideward—to stall predetermined by location of key in panel.

MECHANIZED parking is the engineer's answer to the American motorist whom neither rain, nor snow, nor paralysis of traffic can stay from driving into the city.

Strange and ingenious contraptions have appeared: lift-'em-and-stack-'em systems, big as a building, that pigeonhole cars neatly on steel shelves; hydraulic



5 DISCHARGING, conveyor sets car down on grids in stall. Insertion of key later, when motorist returns, reverses process, delivering car to entry. This is Speed-Park (NYC) system.

Pushbutton Parking

SEMI-AUTOMATIC



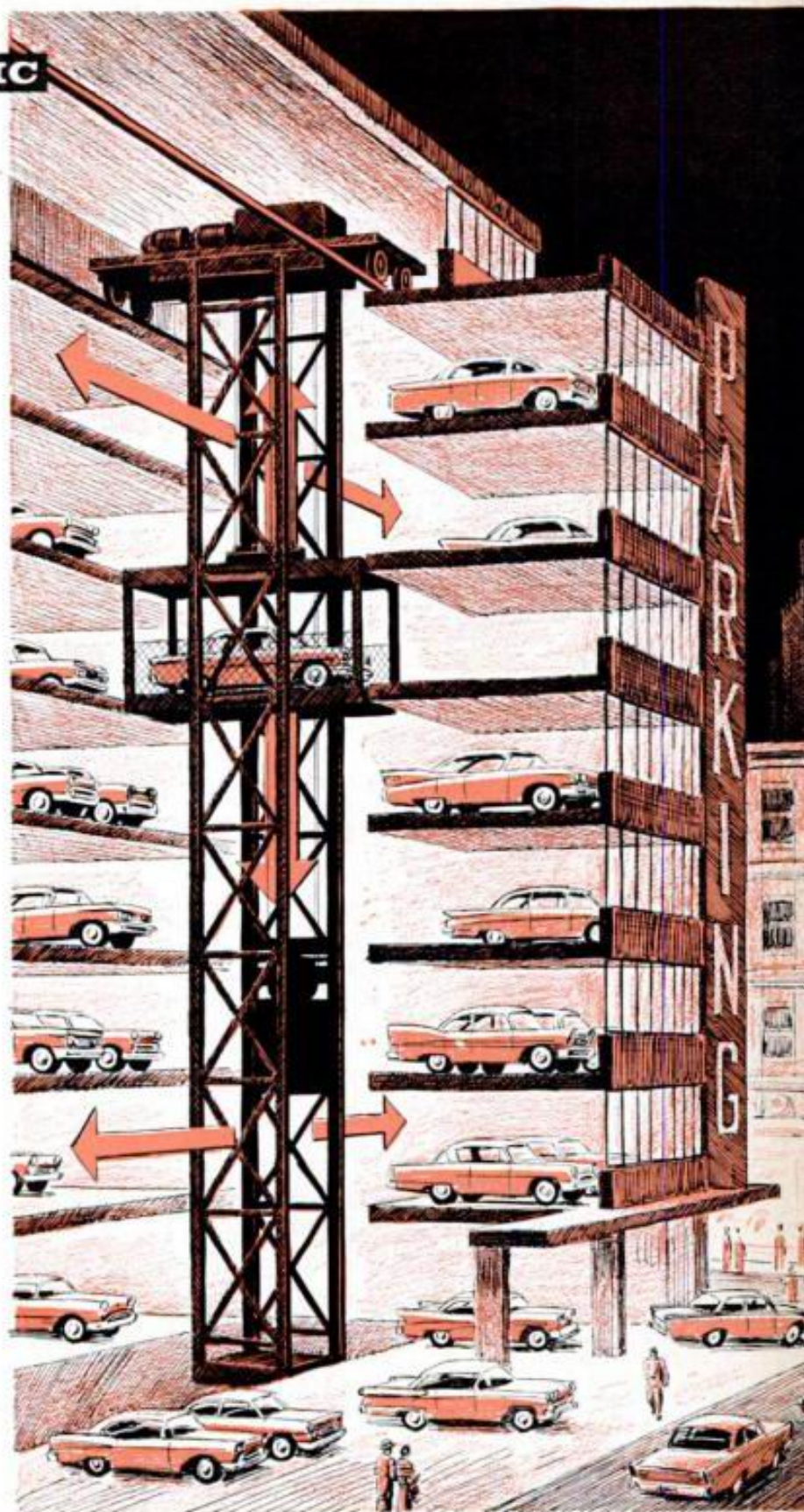
1 ENTERING, motorist gets receipt for his car from attendant. Receipt stub is then placed in a pneumatic tube, which shoots it ahead to a girl at the control panel.



2 AT CONTROL PANEL, stub is inserted in an empty slot (there's a slot for each car stall). This lights a signal in the elevator, showing attendant where the car is to go.



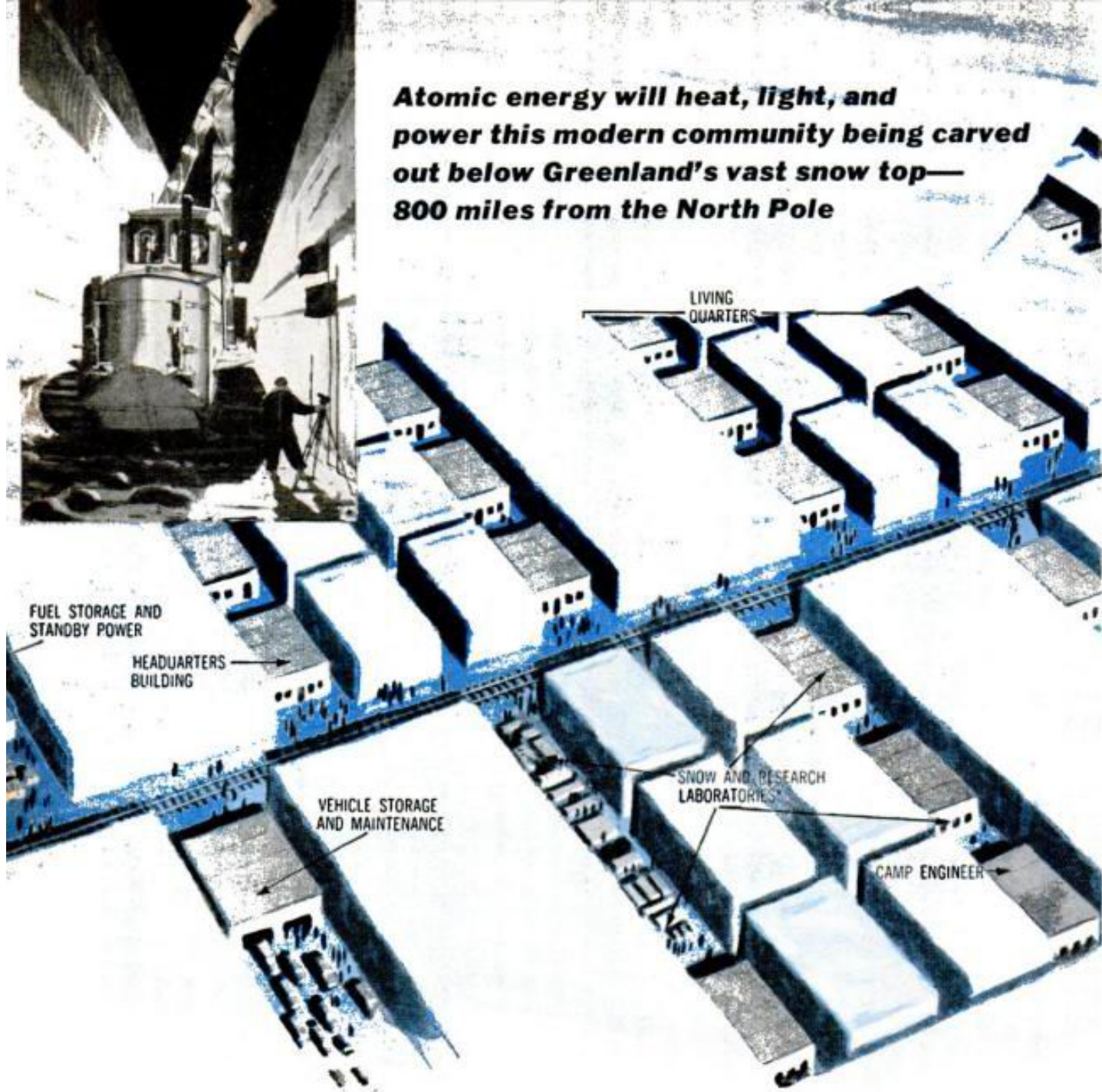
3 DRIVING CAR into elevator, attendant punches a button next to the signal light. This closes the safety gates and sets the elevator machinery into motion. System is made by Bowser, Des Moines, Iowa.



4 SUSPENDED ON RAILS, elevator tower rolls toward designated stall as elevator rises. Attendant then drives car off. When motorist returns, his receipt is checked against stubs on control panel to locate car, and the process is reversed.

CONTINUED

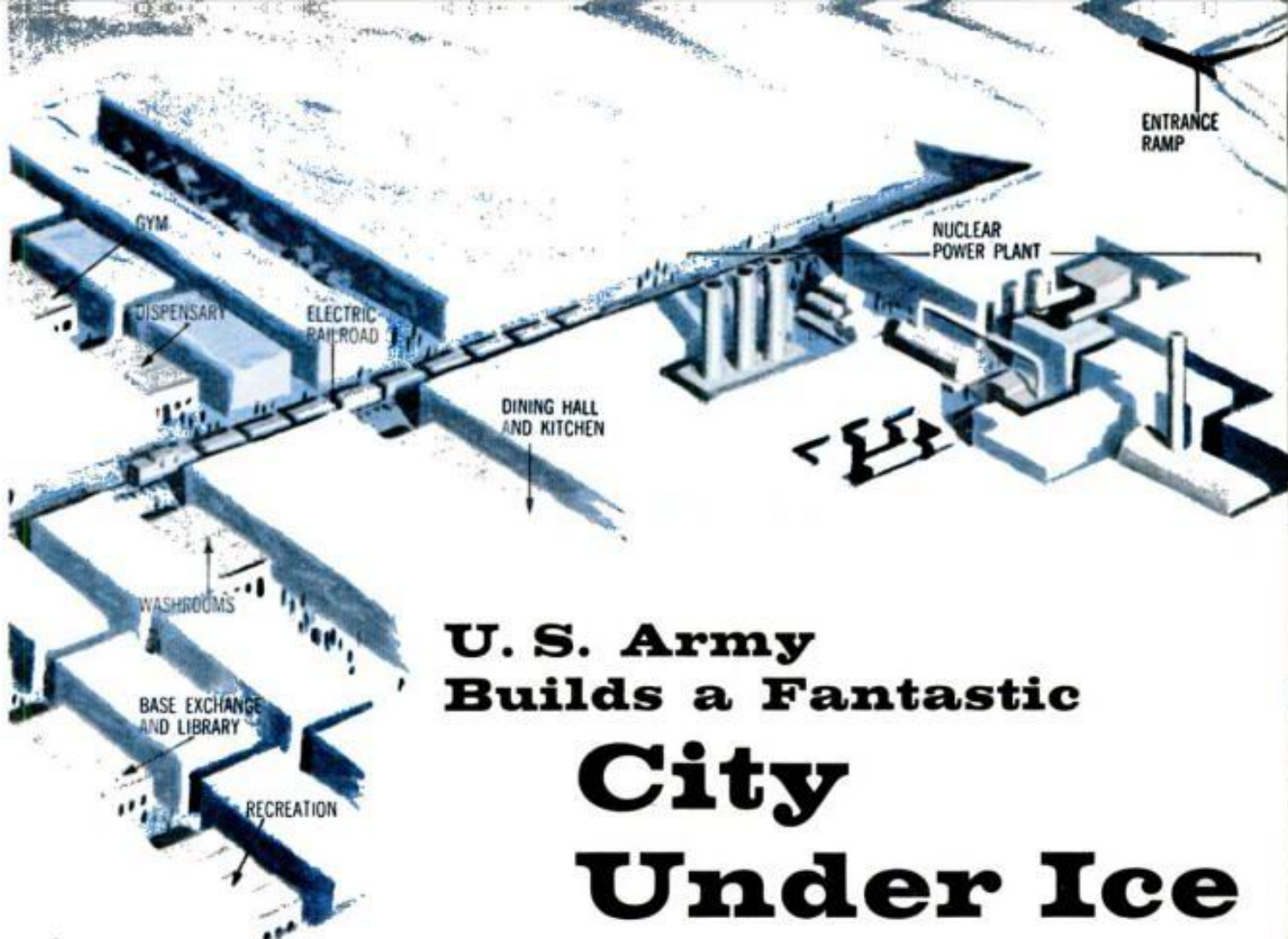
Atomic energy will heat, light, and power this modern community being carved out below Greenland's vast snow top—800 miles from the North Pole



RAMP ENTRANCE of compacted snow will provide access for heavy snow vehicles. Doors will be overhead garage type. Blast in the background is from an under-snow explosive charge.

CUT-AND-COVER PROCESS starts with a shallow trench. Guide rails in walls insure that snow plow will follow correct line and grade. Here the guide platform is being adjusted.





U. S. Army Builds a Fantastic City Under Ice

By Herbert O. Johansen

THE strangest boom town in the world is being built by Army engineers under Greenland's vast icecap. Completely hidden by snow, it will be powered by atomic energy—and will be about as safe a place as you could find in case of atomic attack. It would be hard for an enemy to find; and snow would absorb much of the shock of an atomic blast, and partially shield the occupants from radiation and fallout.

PETER SNOW MILLER, attached to guide platform, cuts deeper with each pass, down to a depth of 24 feet. When finished, Camp Century alone will have more than six miles of tunnel.

CORRUGATED METAL STRIPS form a temporary roof, after cut has been made. Powdered snow, blown back over it, hardens fast. Metal forms are then removed from inside and used again.



CONTINUED



The Fabulous and Deadly **B-70**

EARLY in 1962, this weird-looking bird, the world's fastest bomber, is due to try its triangular wings. Enough details have now come out to make possible this artist's conception.

The Valkyrie, as the Air Force calls its 2,000-m.p.h. B-70, will be a lethal blend of plane and missile. Driven by six jet engines, each developing 25,000-lb.



thrust, it will fly intercontinental missions in incredibly few hours without refueling. It will be able to deliver a massive H-bomb load. In addition, it will carry nuclear missiles designed to dart off at other targets 1,000 miles away.

The B-70, being built by North American, will flash so fast through the thin, frigid air 70,000 feet or more above the

earth that its skin temperature will rise several hundred degrees. But its four-man crew will be snug in a sealed cabin.

About 170 feet long, the 250-ton bomber will have a span of around 115 feet. Stubby frontal controls and two tall tail fins will help it maneuver. It will protect itself with electronic devices instead of guns.—*Wesley S. Griswold.*

A Dream Clubhouse for Space-Age Boys

TOMORROW'S kids will play with solar energy and atomic batteries. They'll tinker with radar and spacecraft engines. To match those advanced hobbies, the Boys' Clubs of America asked designers to plan "Boy-Topia," a clubhouse of the future, with:

- An aircraft work area and shops
- Television and radar labs
- A central building with library, lecture halls, lounge and observation tower

The traditional stadium, swimming pool and gym are there, too. Most facilities will be housed under parabolic-arched plastic shells, either air-supported or poured over metal frameworks. Designers were Griswold, Heckel, and Keiser Associates, Inc., of New York.



Building design reflects space age curves



The social center houses a theater and community hall under a canopy.



Four cable-supported arches frame the central complex. Rising above it is the observatory.



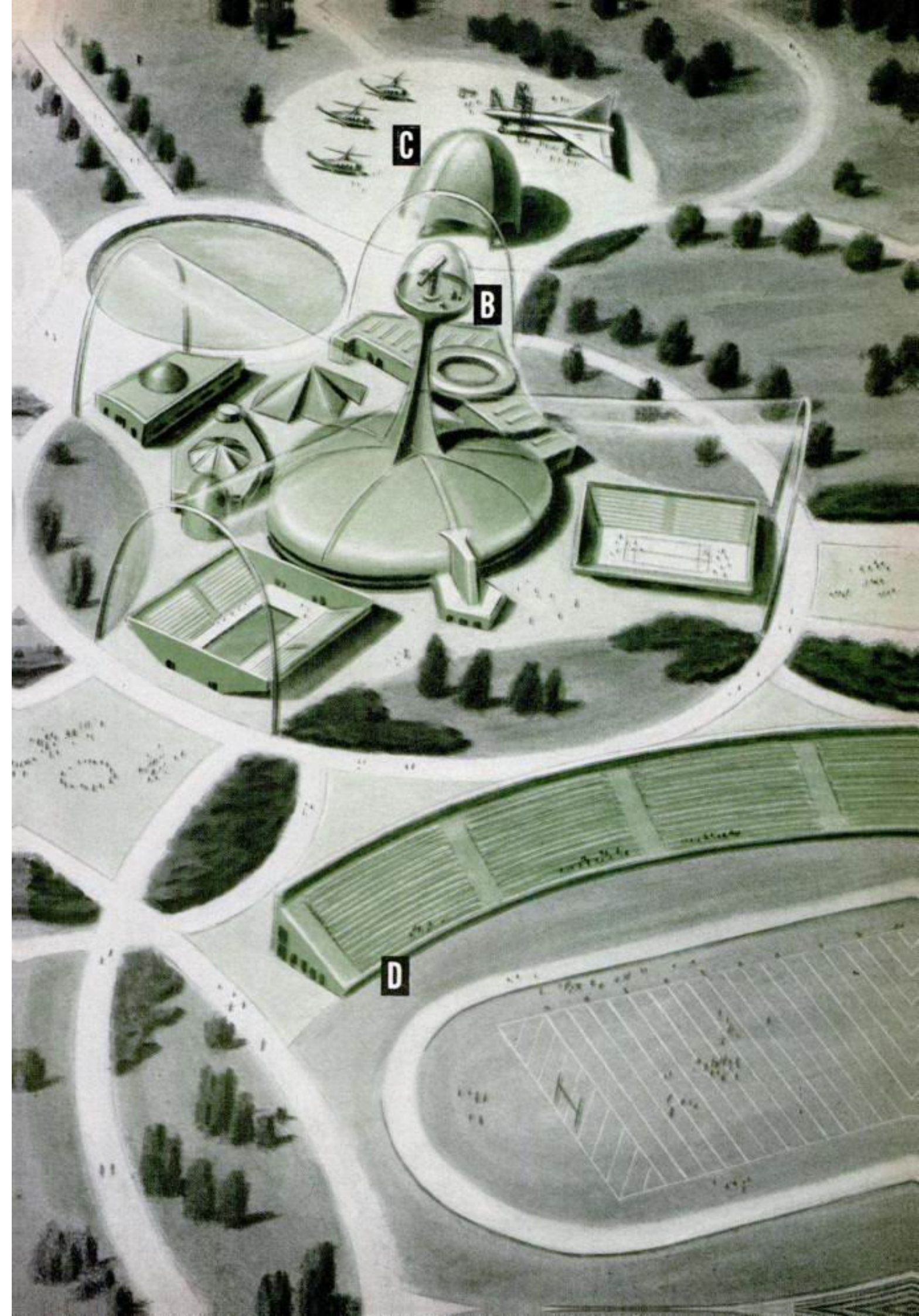
Radar and television labs are set off in the aircraft work area.



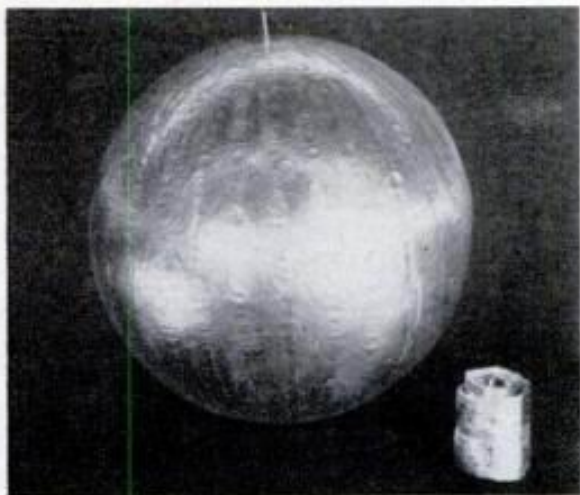
The football stadium will fend off weather under a movable plastic roof. It'll be sprayed over elliptical metal ribbing. The effect—somewhat like a snail snug in its shell.



In contrast to curved arches, typical housing soars vertically.



Forerunners show how the Echo satellite grew



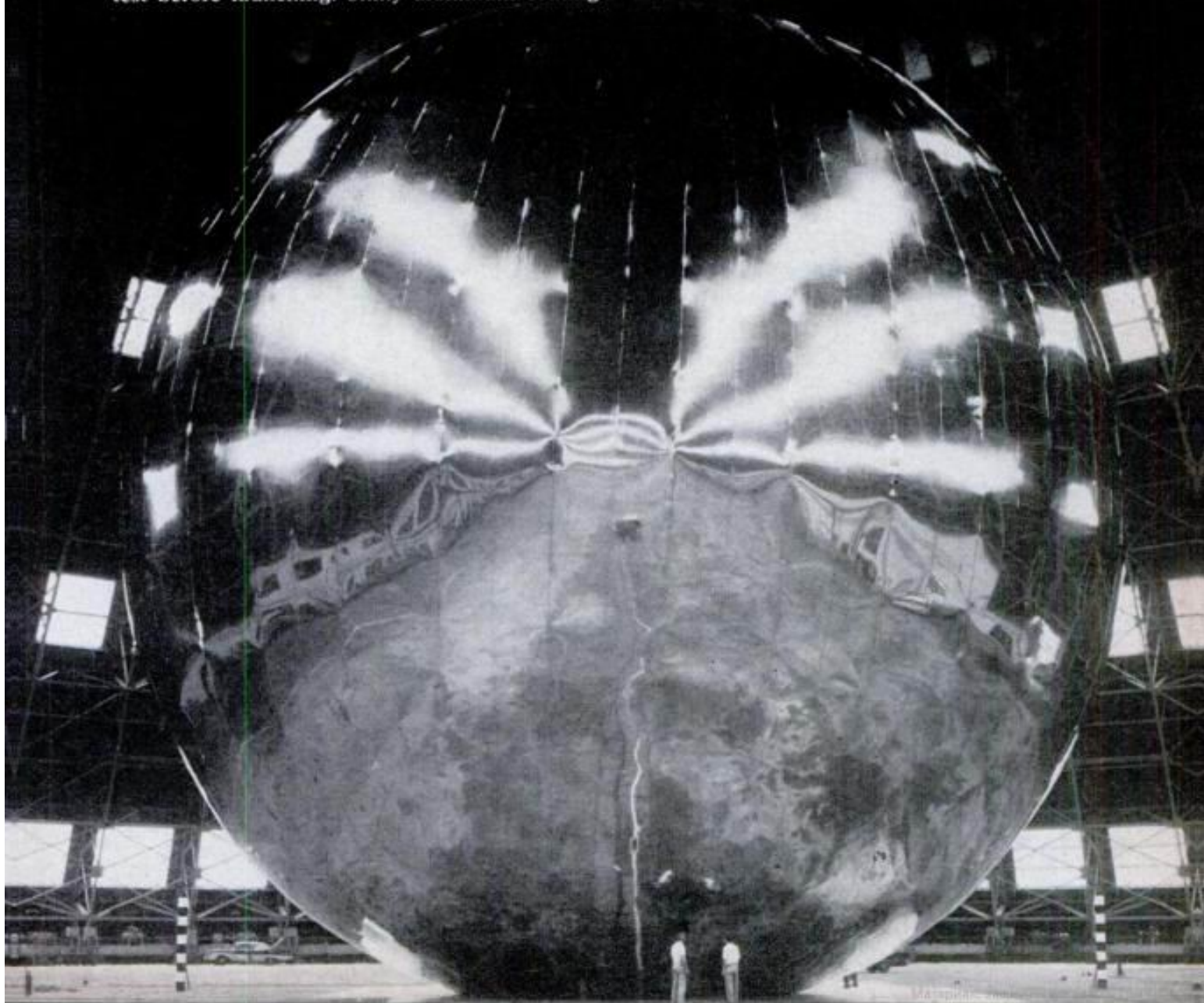
FIRST BALLOON SATELLITE, shown inflated and packaged, was 20-inch one. Similar 30-inch rode Vanguard rocket, got nowhere.



TWELVE-FOOTER came next. Two launching tries, with Jupiter C rocket and Juno II, both failed. Hundred-foot Echo followed.

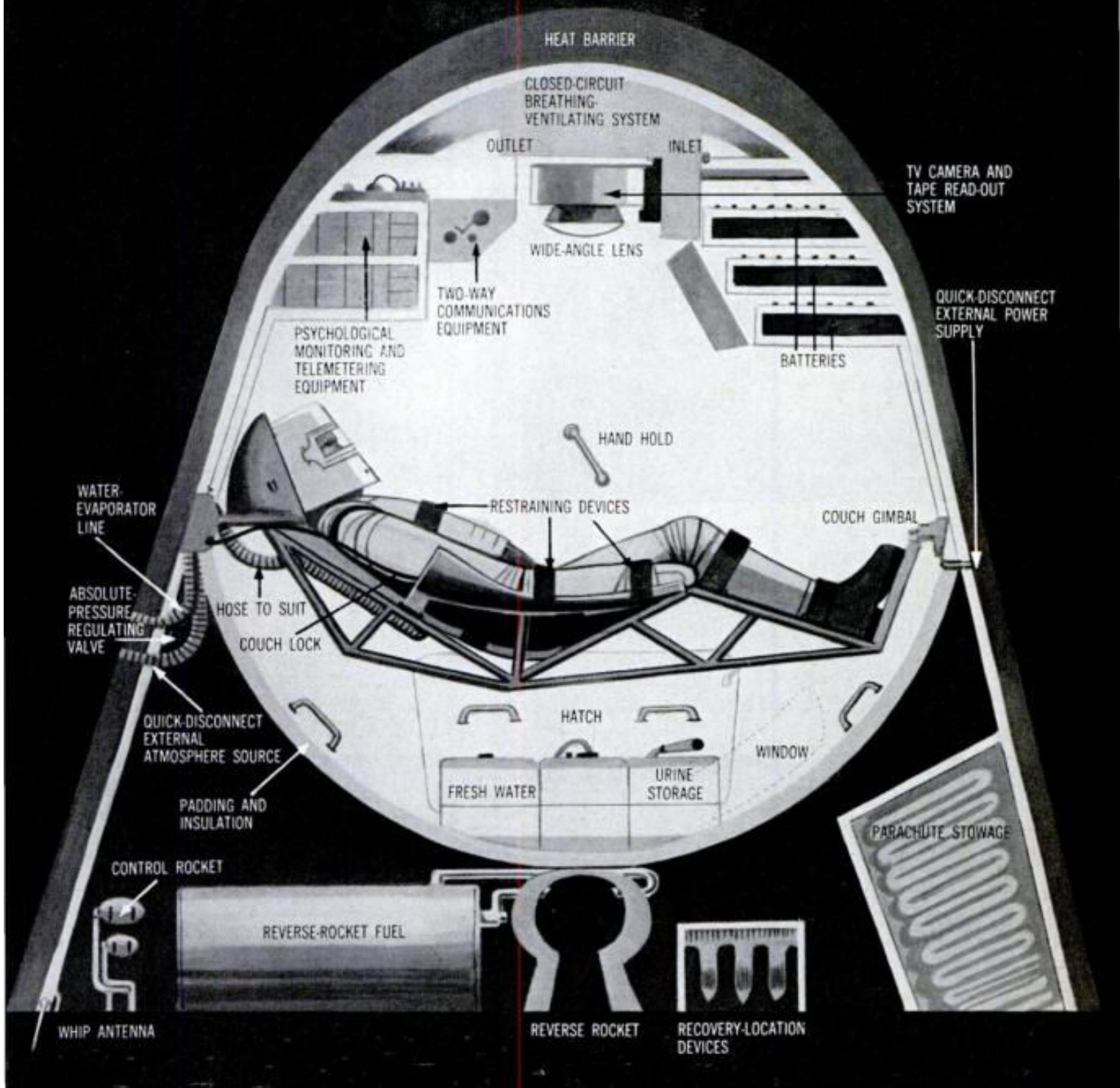
TEN-STORY-HIGH, 100-foot Echo gets air-inflation test before launching. Shiny aluminum coating

for its plastic skin gives satellite high visibility and reflects radio waves back to earth.

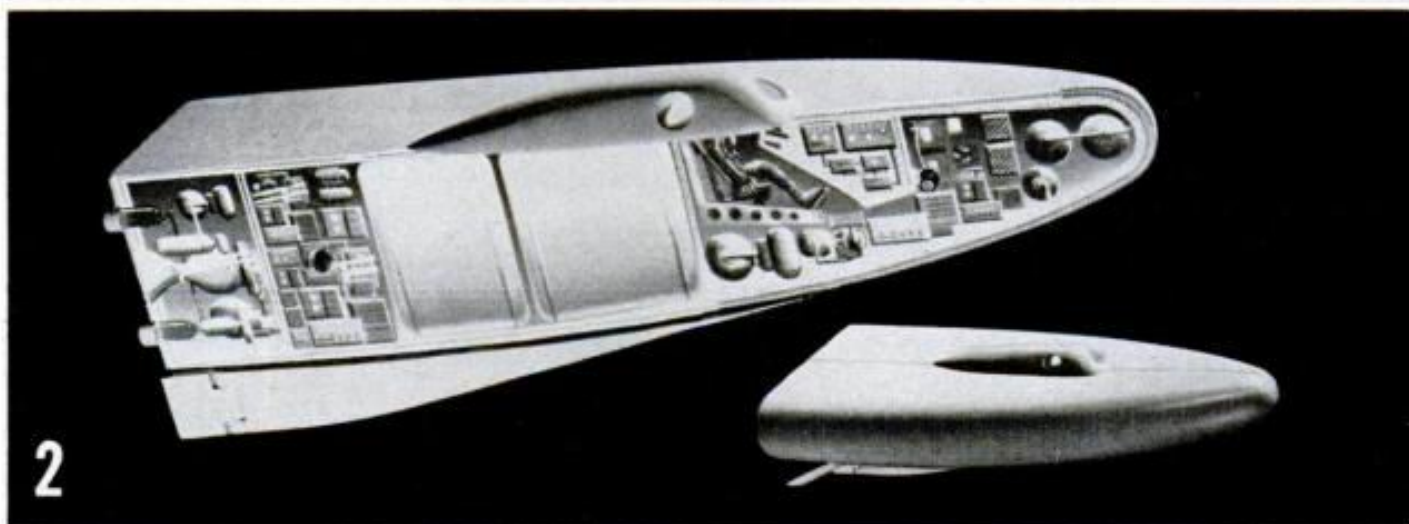
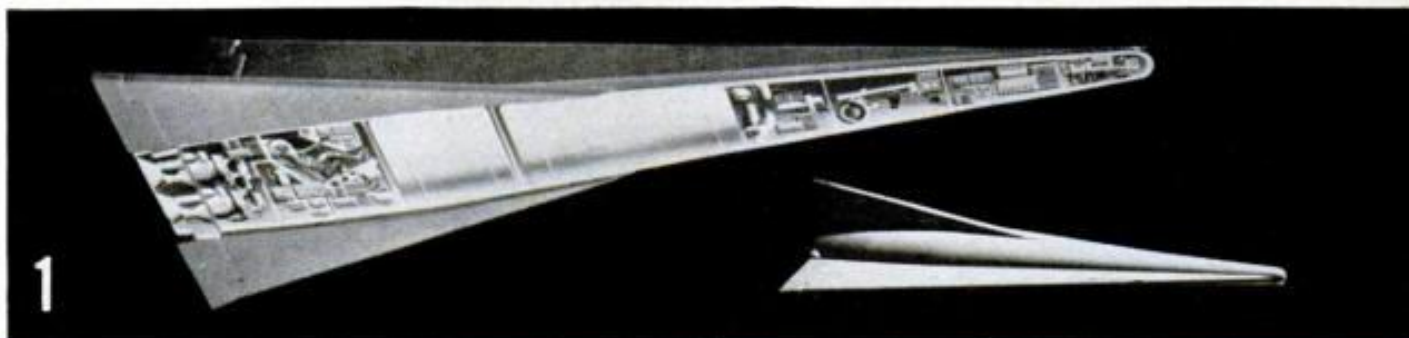


Picture News

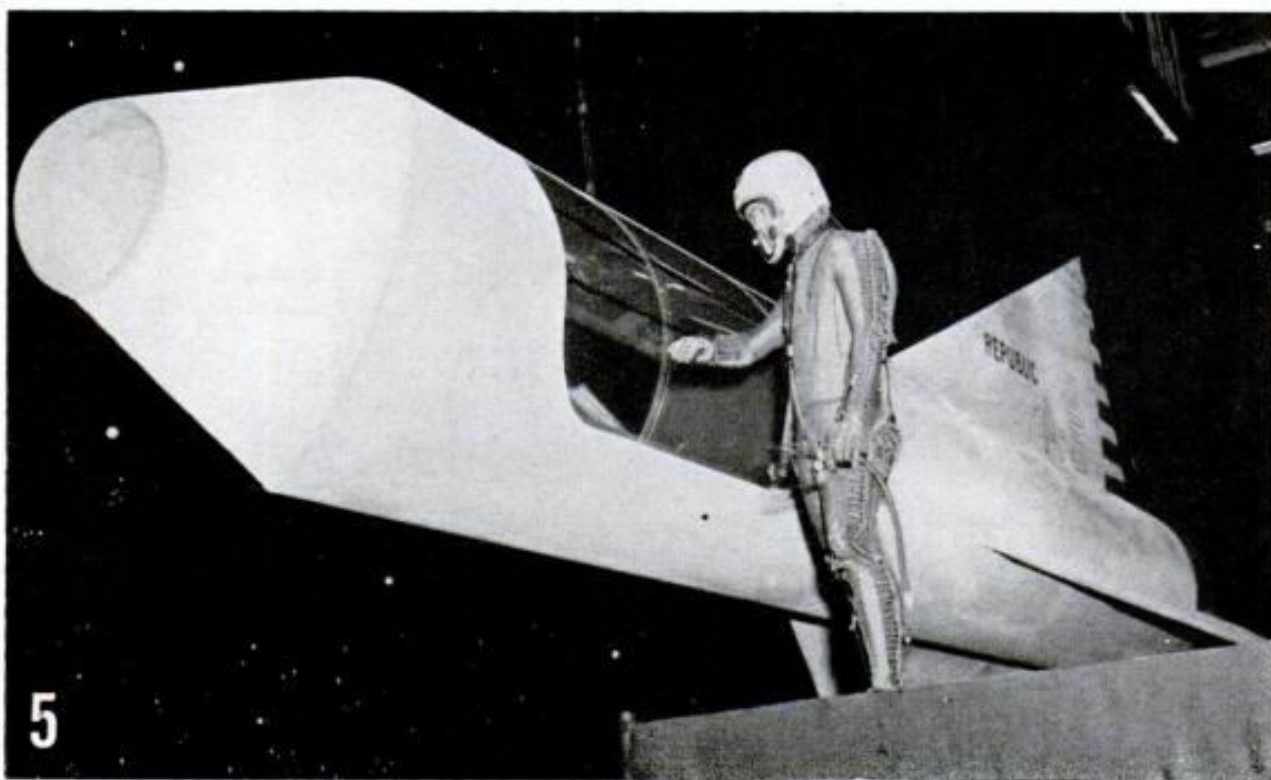
IN THE WORLD OF SCIENCE

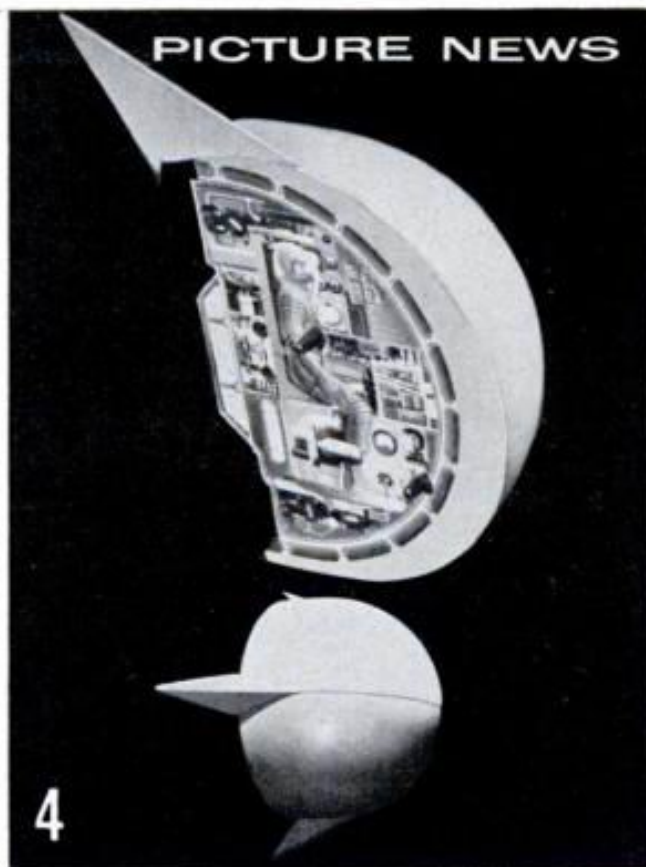
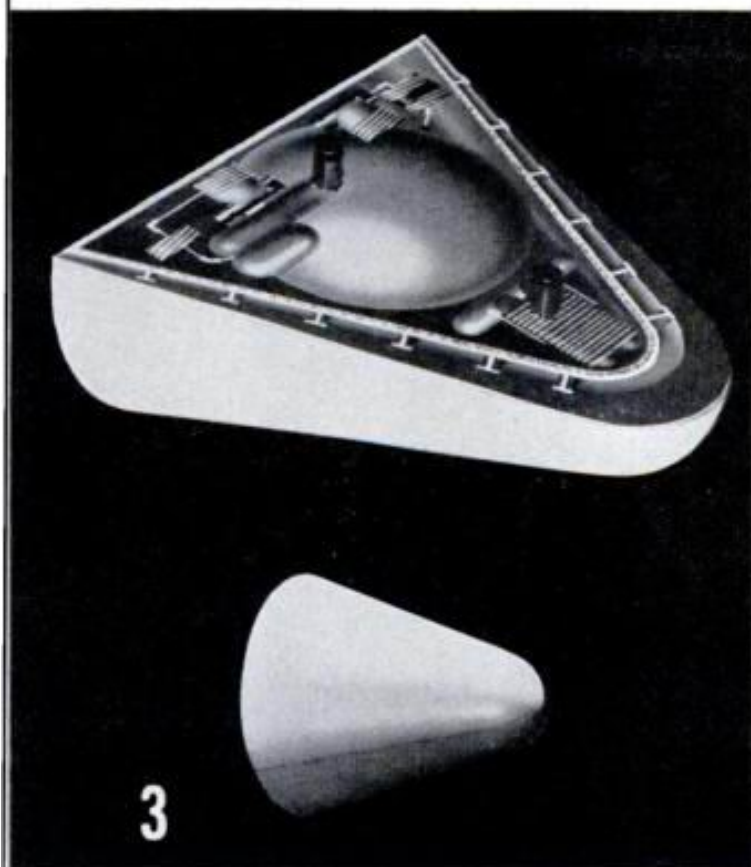


Man in space. Late this summer picked U. S. Air Force personnel start pre-spaceflight training. Here is one way they may eventually go beyond the earth's atmosphere—and return. This conception of an orbital nose cone by *Air Force Magazine* shows the spaceman wearing protective clothing and reclining on a padded couch to protect him from high G forces during acceleration. He will breathe closed-circuit atmosphere; his physiological reactions—heart action, temperature, respiratory rate—will be telemetered to earth. Turn the page for more on manned satellites.



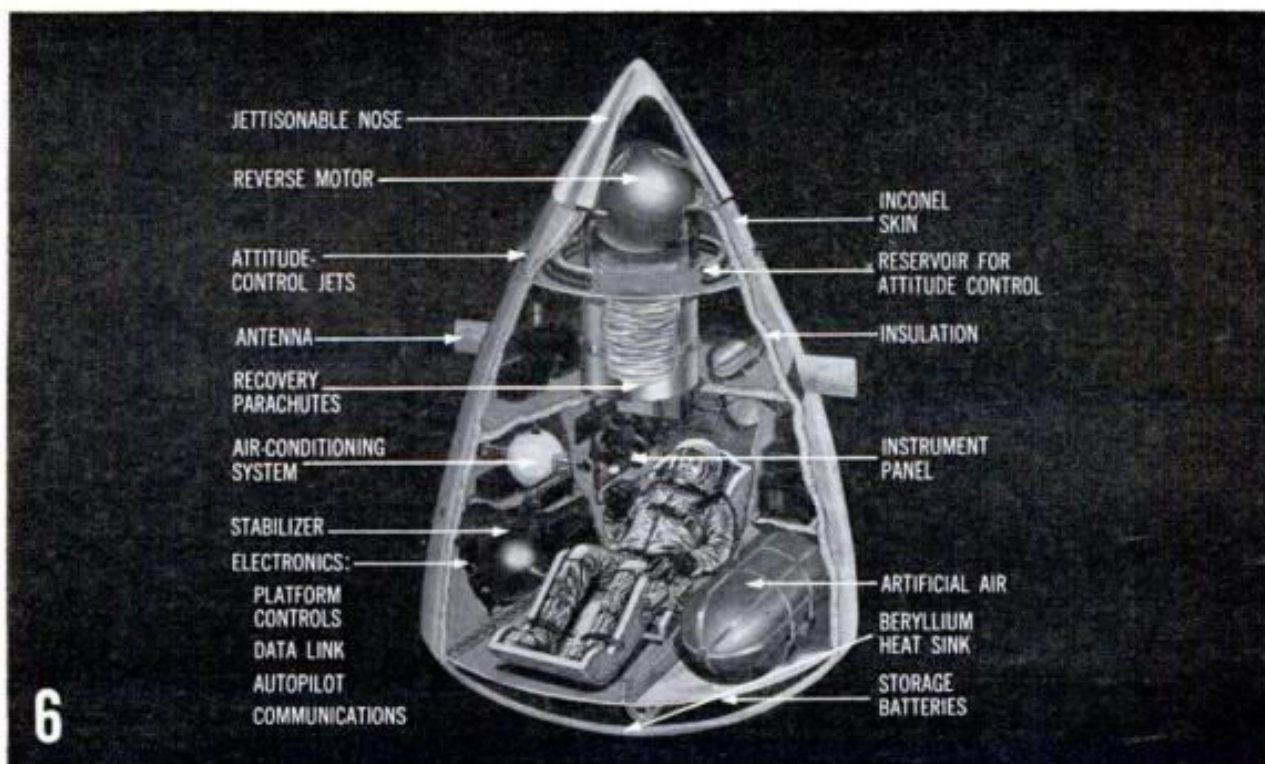
Man in space (cont.) Here are four suggestions by the National Advisory Committee for Aeronautics for manned satellites that could be put in orbit and brought back. A delta-wing vehicle (1) would have a blunt nose and blunt, highly swept wing and fin leading edges to reduce heating. Wider choice of landing area is possible with a "motorboat" satellite (2) that could land on water. Both would have re-entry and landing controls. The ballistic-missile design (3) has a copper-shell heat shield thickest at the nose with an air gap and insulation separating it from the

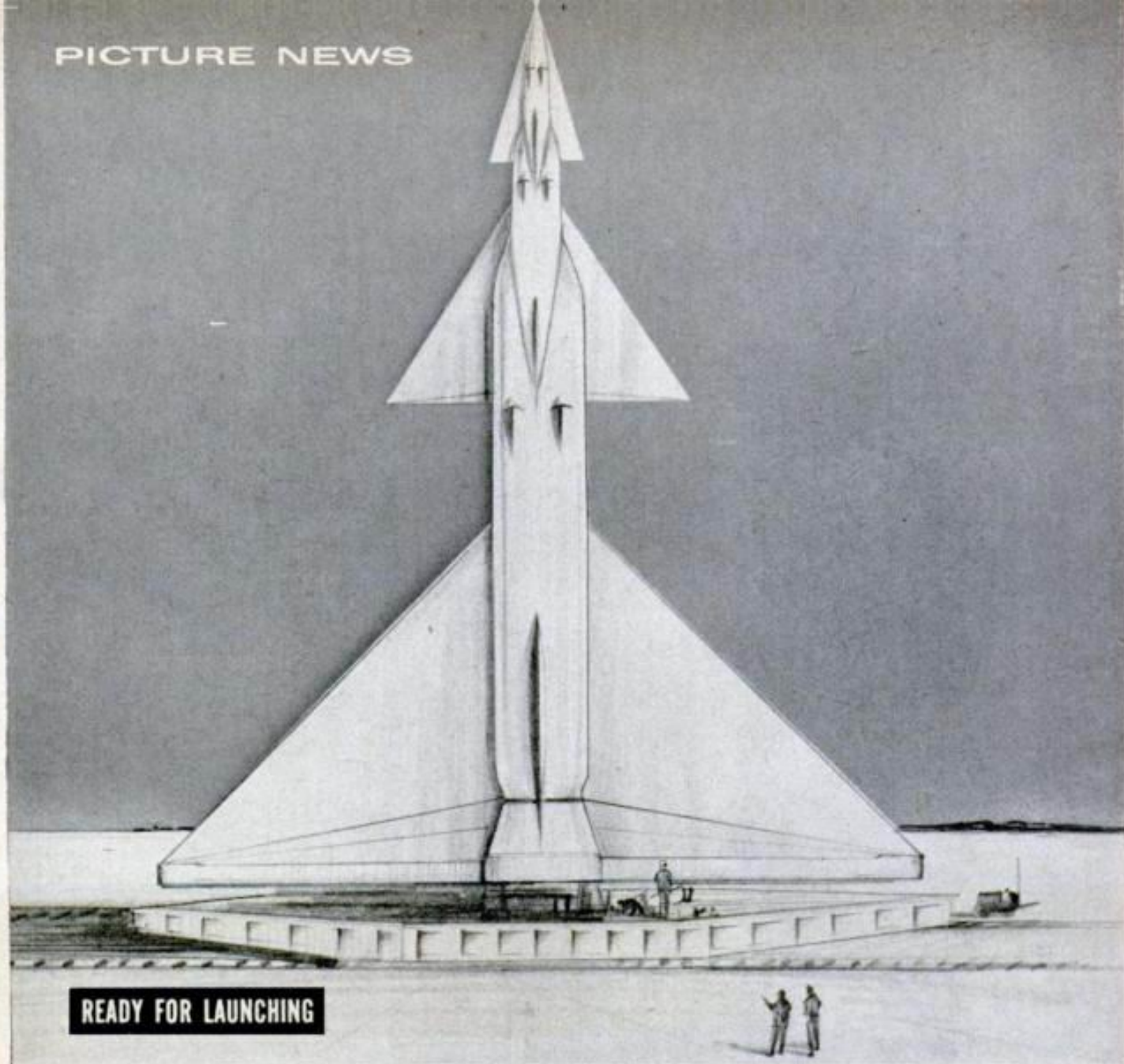




inner capsule. A beryllium oxide outer shell of a hemisphere (4) is insulated on the inside. The man is nearly vertical in launching position.

A 32-foot model of a re-entry vehicle (5) was shown by Republic Aviation in an exhibit dramatizing the possibility of rocket-launched moon satellites and space exploration. Northrop Aircraft has developed a basic design (6) for a recoverable manned "space laboratory" it says could be launched by an existing intercontinental ballistic missile in three years. Contemporary rocket engines would boost it into orbit.



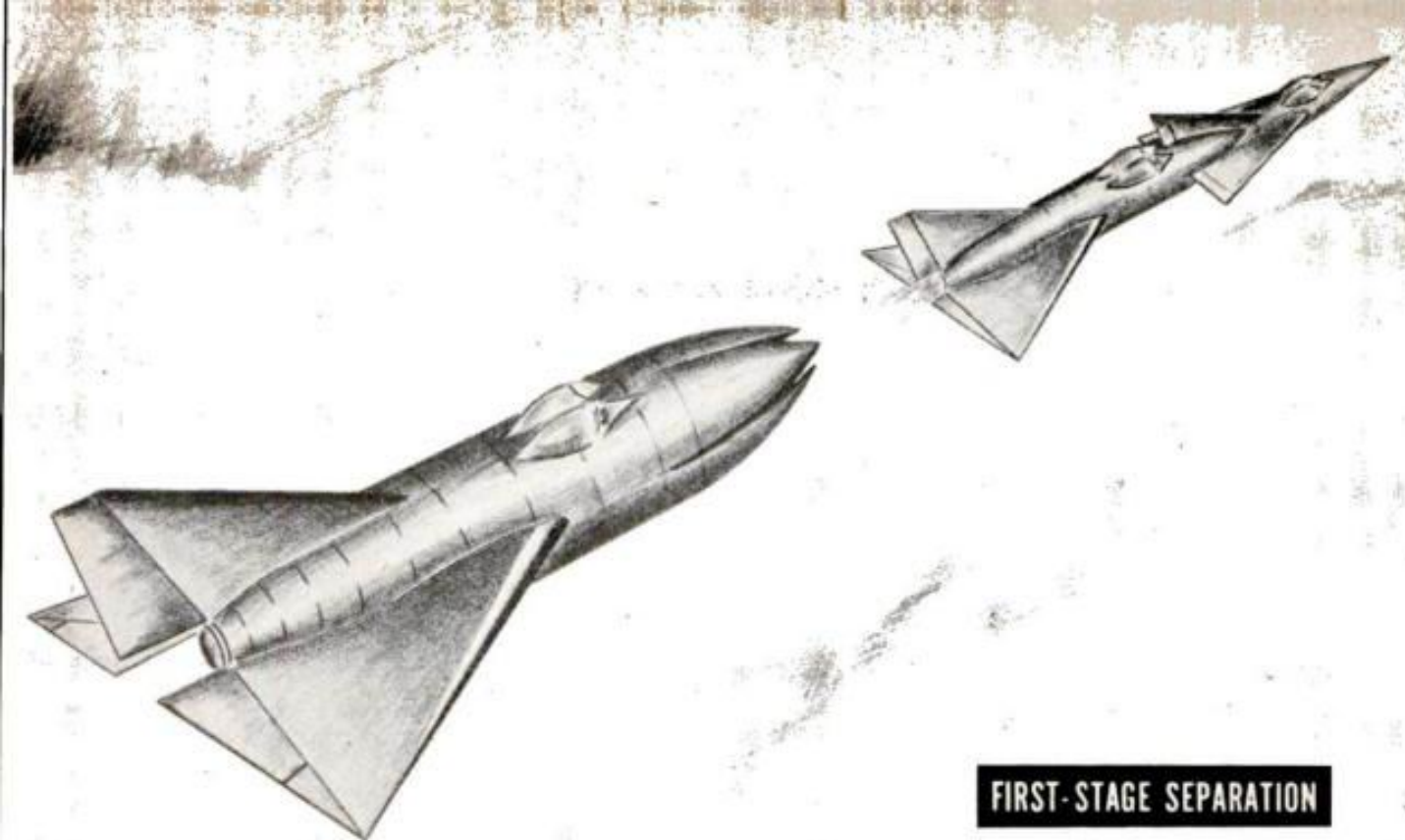


READY FOR LAUNCHING

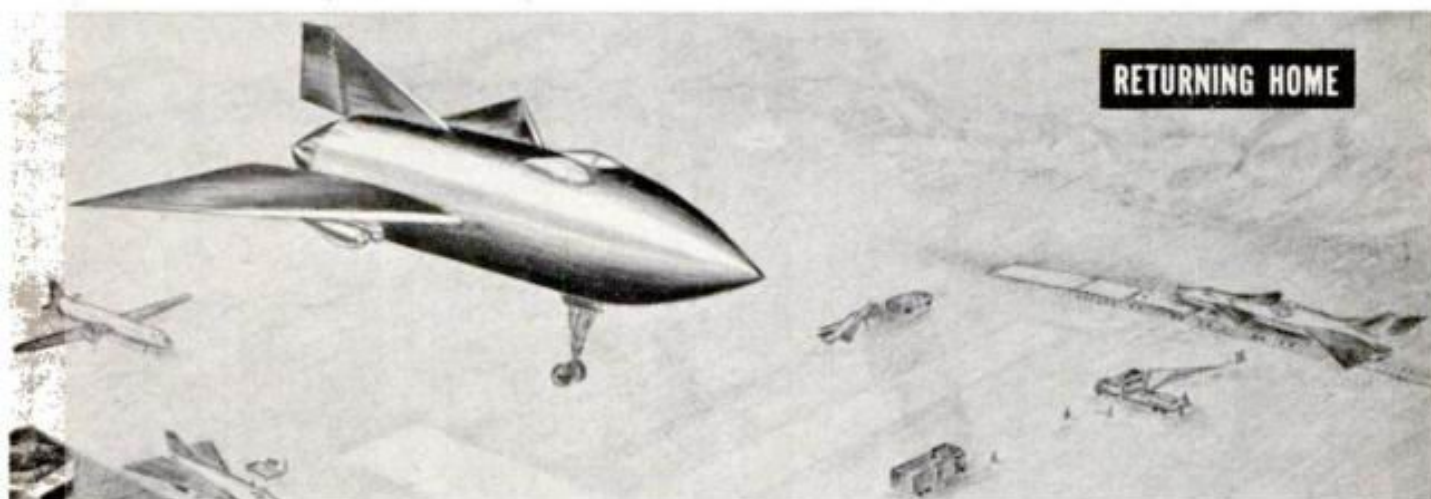
Satellite with crew? By 1965, U. S. experts say

A THREE-STAGE rocket, its third stage to enter an earth orbit and return safely after two months, is proposed by Goodyear Aircraft scientists as a possibility within eight years. A modified version of an earlier design (PS, Apr. '55), Meteor Jr. would be 142 feet long, weigh 500 tons and consist of three delta-winged rockets, each with its own



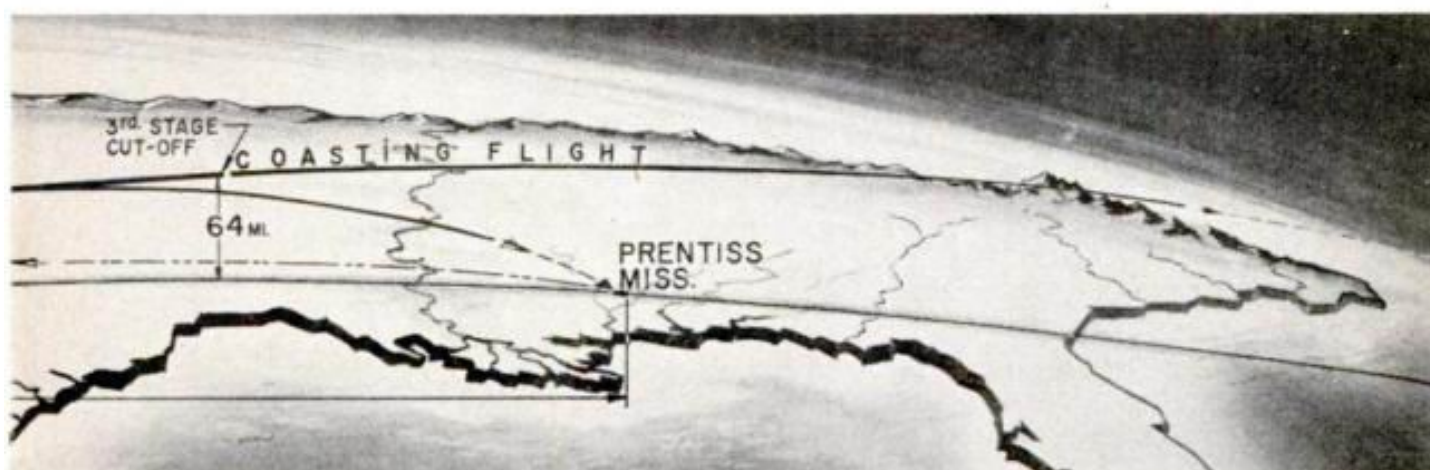


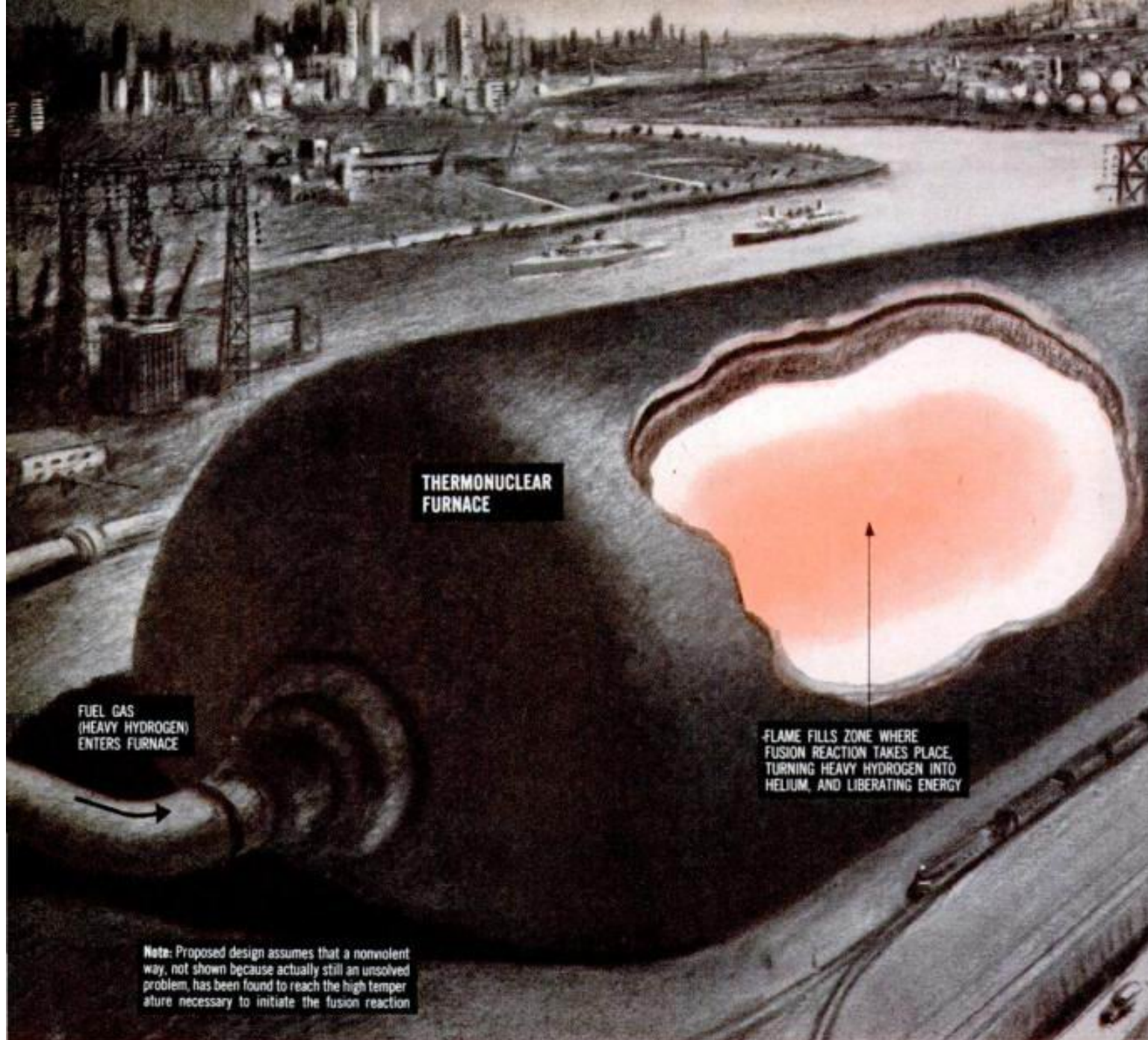
FIRST-STAGE SEPARATION



RETURNING HOME

crew. It would be launched at White Sands. Its booster stage would drop 300 miles away—altitude, 24 miles—its second stage 700 miles farther, 41 miles up. The third stage, with crew of three, would circle the earth 500 miles up at 16,660 m.p.h., with supplies for two months and return fuel. Darrell C. Romick, head of the Goodyear group that designed it, compares its cost to that of the intercontinental B-52 bomber.





Note: Proposed design assumes that a nonviolent way, not shown because actually still an unsolved problem, has been found to reach the high temperature necessary to initiate the fusion reaction

An H-power plant may look like this, one plan suggests. Its capacity would exceed combined

Will This Furnace Yield

HYDROGEN from the sea will furnish us safe and unlimited nuclear power, when we learn to harness the H-bomb's fusion reaction. First, a way must be found to kindle it, less violently than with an A-bomb.

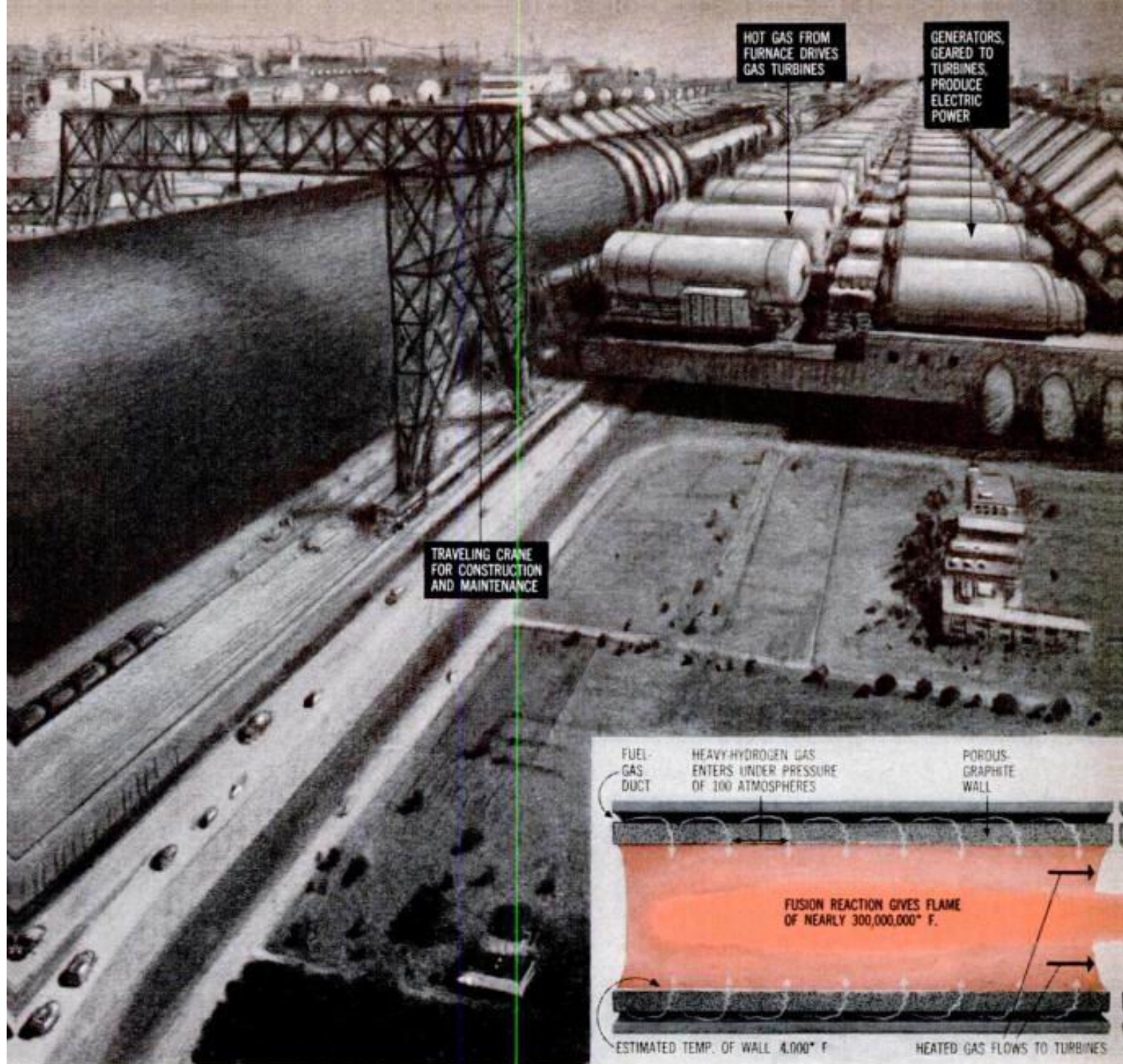
Then comes the problem: What firebox could withstand the sun-hot flame? One possible answer, pictured here, is offered by Dr. Hsue-shen Tsien, former Caltech professor of jet propulsion.

A giant cylinder of graphite forms a

heat-resisting "fusion furnace." Pumped through the porous wall, heavy-hydrogen gas cools it, and fuels the flame within. Hot gas from the furnace drives gas turbines coupled to electric generators.

Unburned fuel in the turbines' exhaust gas is purified of "combustion" products—helium and tritium—and pumped back to the furnace, along with fresh fuel to replace what has burned.

The furnace must be at least 325 feet in diameter and 3,250 feet long, by Dr.



output of all power stations in U. S. today.

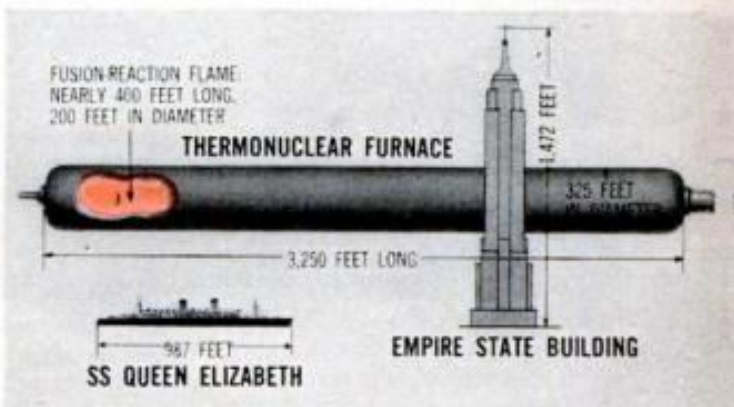
H-Power?

Tsien's figuring. One such plant would produce 300,000,000 kilowatts, more than all U. S. generating capacity today.

Some scientific critics doubt whether gas cooling will suffice to keep Dr. Tsien's furnace from going up in smoke. For many hold that the thermonuclear flame will vaporize any known material, and so can be confined only by an electrical or magnetic field. But most are optimistic that, eventually, all H-power problems will somehow be solved.

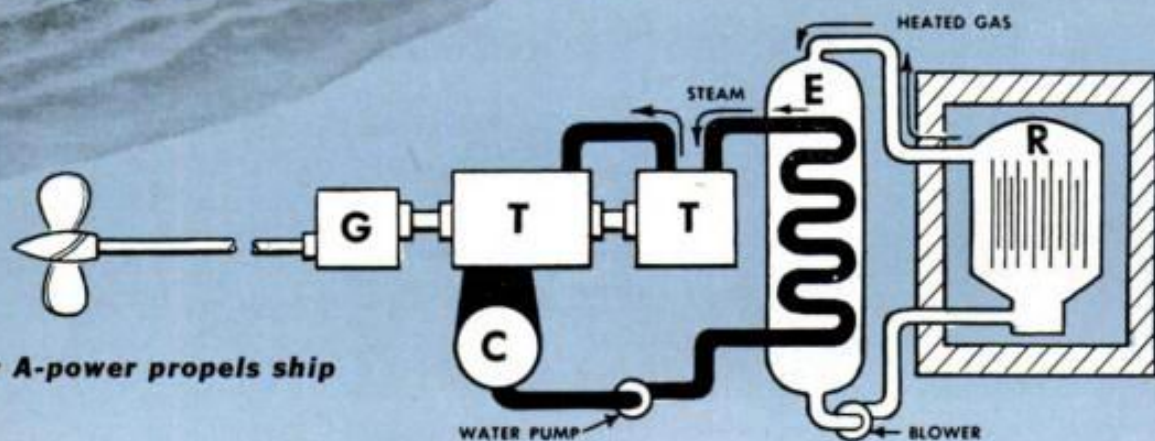
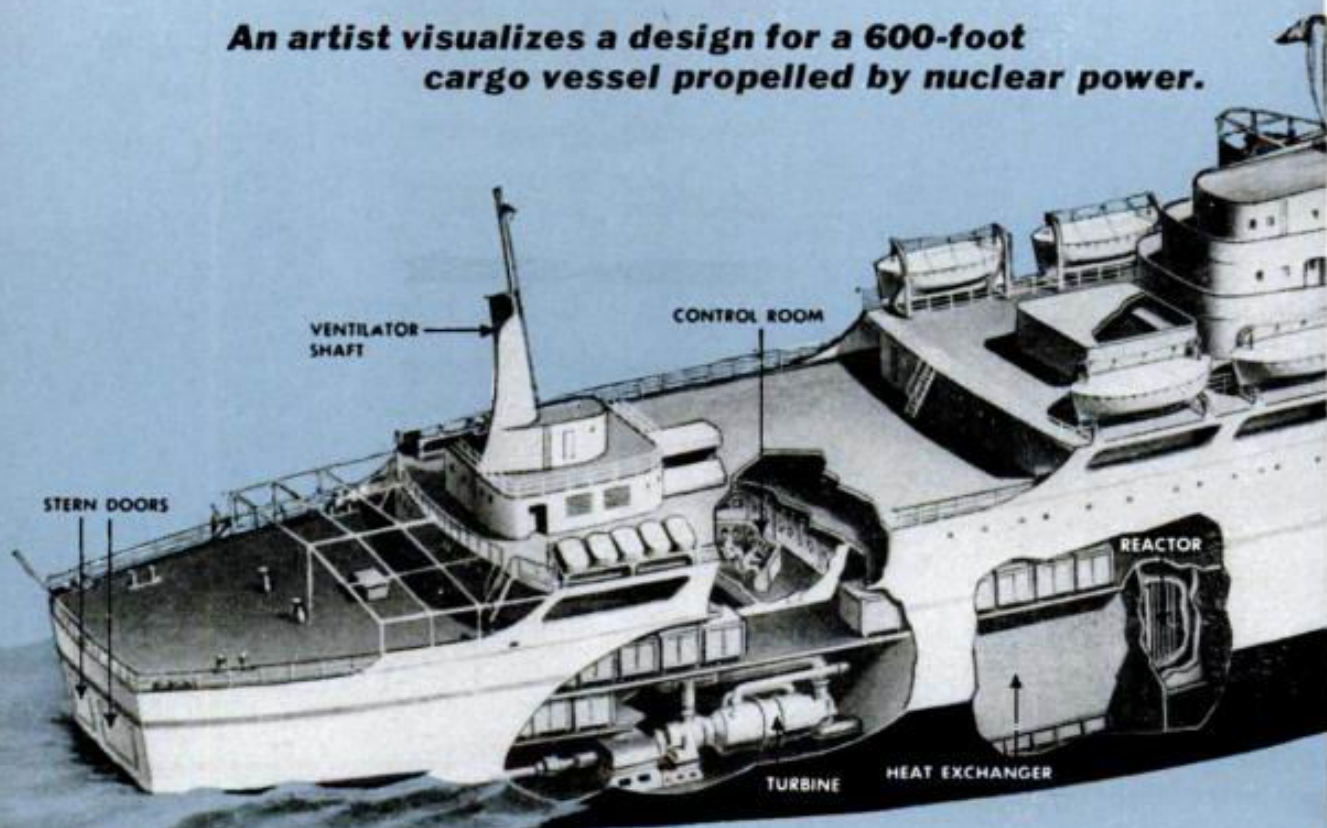


SECTIONAL VIEW of H-power furnace (inset above) shows scheme to enable it to withstand flame temperature of millions of degrees. Incoming fuel gas would cool porous-graphite walls and keep flame away from them, by interposing a zone too cool to support H-reaction. Furnace's giant dimensions are compared below with size of world's largest liner and tallest building.



Atomic Freighter

An artist visualizes a design for a 600-foot cargo vessel propelled by nuclear power.

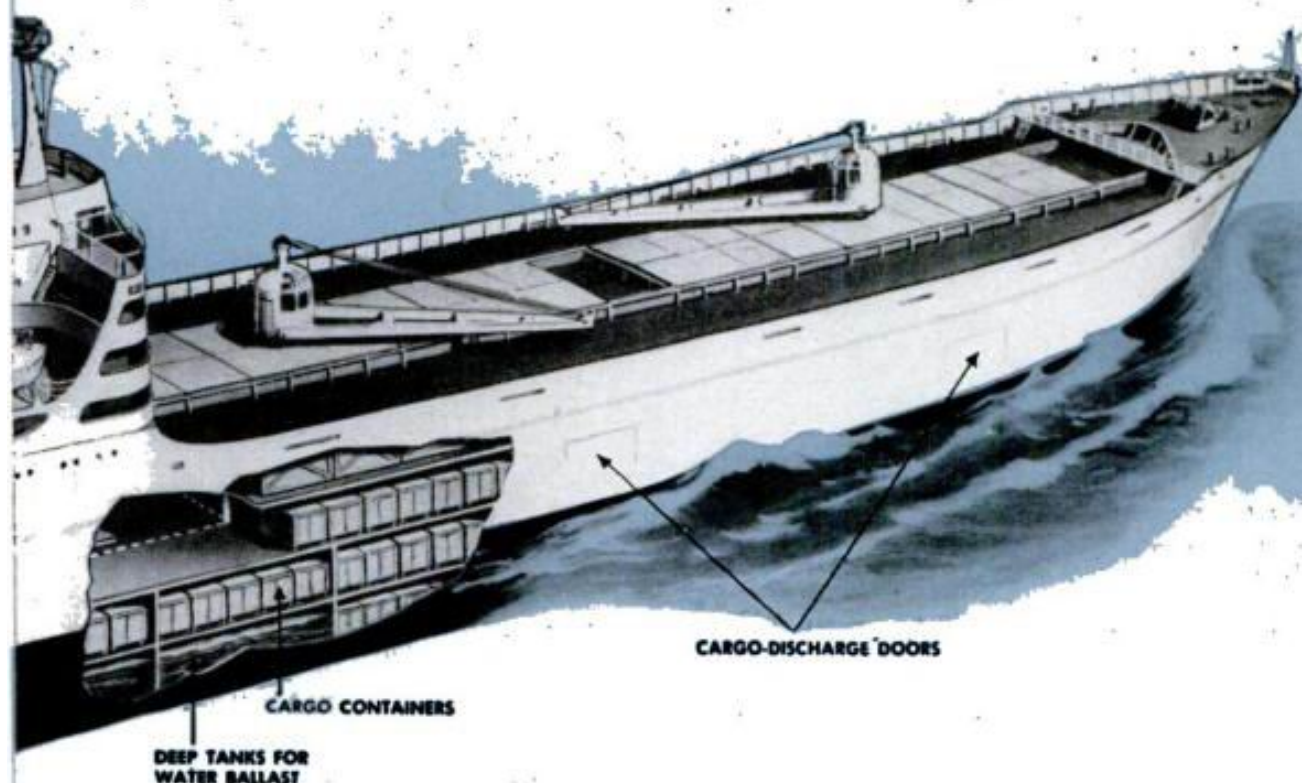


REACTOR (R) HEAT converts water in heat exchanger (E) to steam, which drives turbines (T). Condenser (C) reconverts steam to water. Turbines turn gearing (G) to drive props.

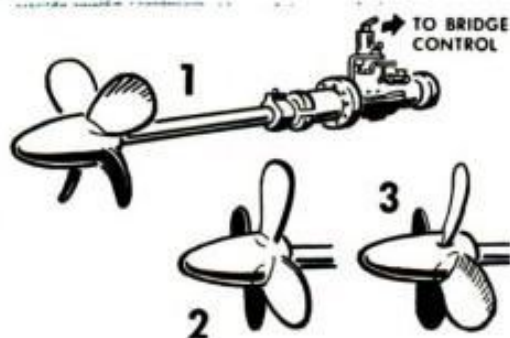
PLANS for atomic-propelled merchant ships are on the drawing boards in England, as in America. Here is an artist's conception of a proposed British design for a 600-foot cargo vessel, of 16,000 to 18,000 tons' carrying capacity, to run on nuclear power.

Heavily shielded amidships, an atomic reactor delivers hot gas to the freighter's boilers, which make steam to run geared turbines driving the main propellers. As an alternative, gas turbines and a secondary hot-gas circuit could replace the steam system.

Planned in England

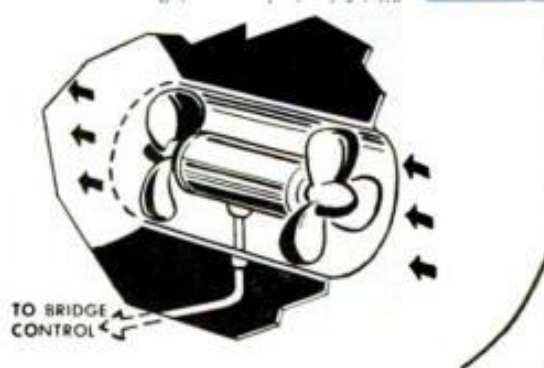


Screws have variable pitch



PROPELLERS, hydraulically controlled from bridge, can change pitch. Diagram above shows: (1) astern; (2) neutral; (3) ahead.

Auxiliary propellers, at bow, aid in maneuvering



REVERSIBLE BOW PROPELLERS, also controlled from bridge, fit in tube running athwartships. Watertight motor in tube runs them.

Innovations in the vessel's design include a transverse tunnel, below the waterline near the bow, fitted with reversible auxiliary propellers to aid in maneuvering and docking. Lower decks carry freight in easily handled containers, which are designed to fit into railroad

cars as well; and electric cranes stow general cargo above.

The artist's drawing is from the *Hunting Group Review*, the London publication of a worldwide group of companies whose list is headed by the British shipping firm of Hunting & Son Ltd.

New in Aviation

Jets Shoot for New Records



Deadliest of the aircraft in the news this month is the Snark (at left), first U. S. guided missile with enough range to cross oceans. Developed by Northrop Aircraft, it can tote an atomic warhead. Guided by radio from Patrick Air Force Base—the site to be used in launching our artificial earth satellites—it has winged 2,000 miles.

Biggest plane is on the drawing board and would be driven by atomic power. Its dreamer-upper, Lee Ohlinger of Northrop, says it could fly almost indefinitely. As a Leviathan bomber, it would tow a flock of fighters until danger developed, then cut them loose. As a commercial "locomotive," it would tow airliners on airlines all over the world.

Plushiest is a four-jet airliner (at right) just announced by Convair. It will cruise at 609 miles an hour in vibrationless luxury. As a first-class plane, it will seat 80 passengers; as a low-fare tourist plane, 99.





Sauciest plane is a twin-jet Russian Tupolev Tu-104 that flew into London Airport, startling observers this side of the iron curtain. It seats 50 passengers and probably can fly more than 500 miles an hour. Weighing about 75 tons fully loaded, it's about the size of Britain's Comet III.

Experts say that the plane is adapted from the Reds' Badger bomber.



Fastest timed mile ever flown is claimed by Britain for this Fairey Delta 2, which was clocked officially at 1,132 m.p.h. in level flight. U. S. F-104A (see page 74) is reported, unofficially, to be even faster.

For more picture news in aviation, please turn the page ➡



Now They're Planning

Expansion-house techniques would be used in giant

By Herbert O. Johansen, with drawings by Ray Pioch



Darrell C. Romick

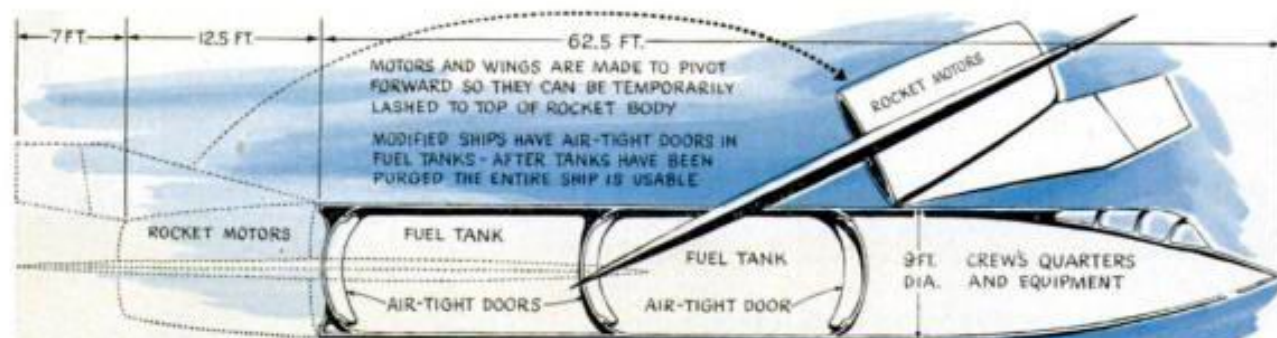
THIS is a design for living in space: a dream that will not, of course, come true for many years. It goes far beyond even the proposals for rocket ships or large, manned research satellites that may follow the artificial baby moons scheduled to be launched in 1957-58 as part of the International Geophysical Year.

The drawings are based on an engineering study by Darrell C. Romick, a scientist in the Goodyear Aircraft Company's aerophysics department, who

a majestic wheel turning slowly to simulate earth gravity. They would work in a gigantic, 3,000-foot-long, gravity-free structure equipped with scientific laboratories, telescopes, radar, earth-scanning television cameras—with facilities for docking, launching and repairing rocket ships, and even constructing them for the exploration of outer space.

Last year Mr. Romick presented to the American Rocket Society a proposal for a three-stage rocket, the last stage of which would be a ferry vehicle to supply a space station (PSM, Apr. '55, p. 138). Now Mr. Romick, in a sequel engineering study, has shown how such ferry-stage rockets could become the initial building blocks for a space station.

As needs arose, it could be expanded



Ferry rockets would be adapted in space to become initial building units for the station.

worked with artist Ray Pioch in preparing this presentation of his proposal for **POPULAR SCIENCE MONTHLY**.

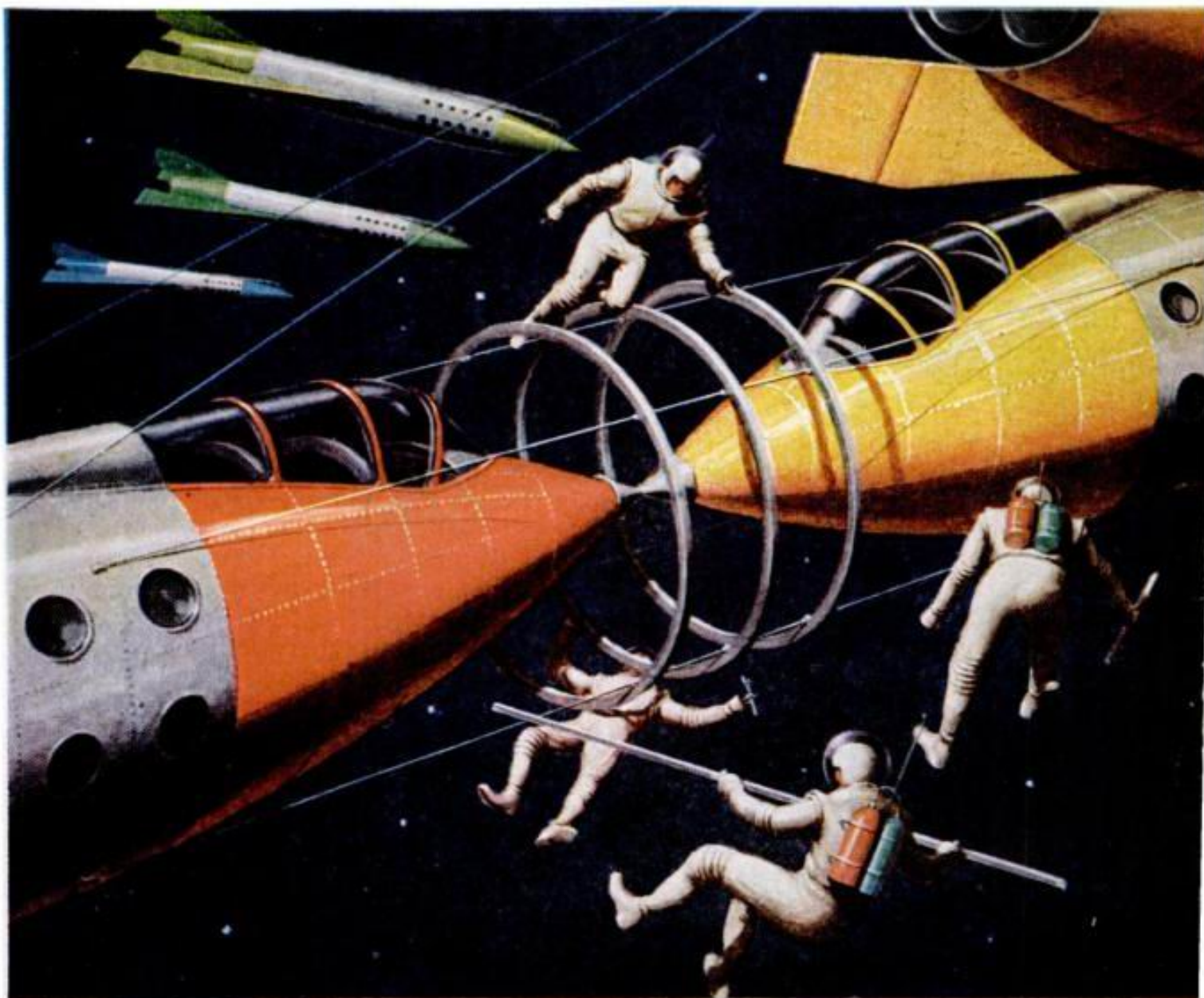
Mr. Romick's study is a bold blueprint for an *inhabited* space station, a sky city that would house thousands of people. They would live normal family lives in

until completed years later as a vast earth-orbiting community. Solar energy would be utilized for power. There would be apartments, theaters, gymnasiums, supermarkets, a hospital.

On the next six pages the details, as envisioned by Mr. Romick, are shown.

a City in Space

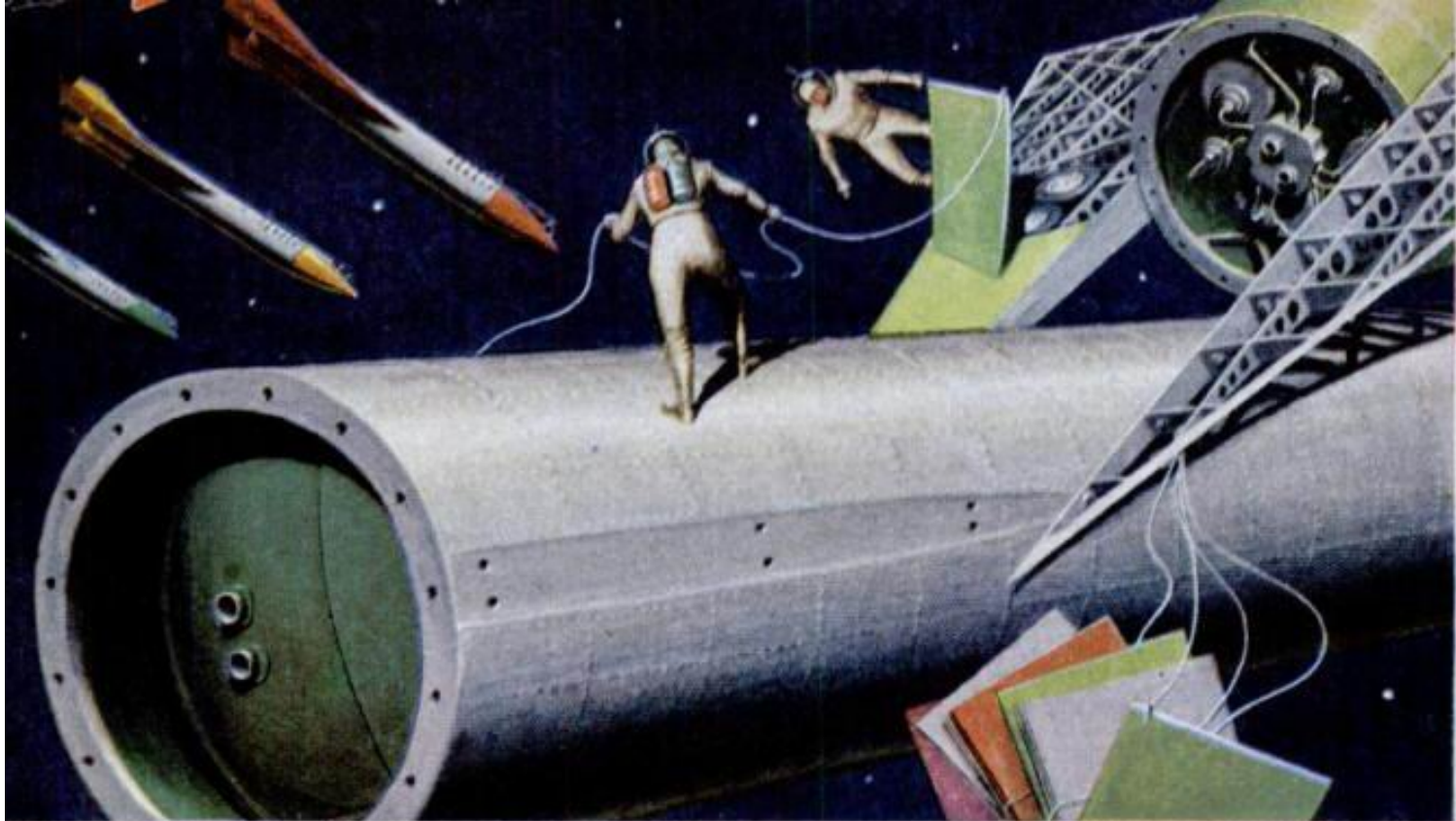
earth satellite, built to accommodate 20,000 people.



1st Day With the first two ferry rockets nosed together, construction crewmen, wearing pressure suits, will attach cables to them and to support rings that will be skinned over. Rear wing and motor sections have been swung forward (cut-away on opposite page) to be handy for

use later. Fuel tanks have been cleaned so that the entire length of the rockets, nine feet in diameter, can be used as temporary living and working areas. Rockets are pressurized so that space suits need be worn only for outside work. Three emergency ships stand by.

MAY 1956 93

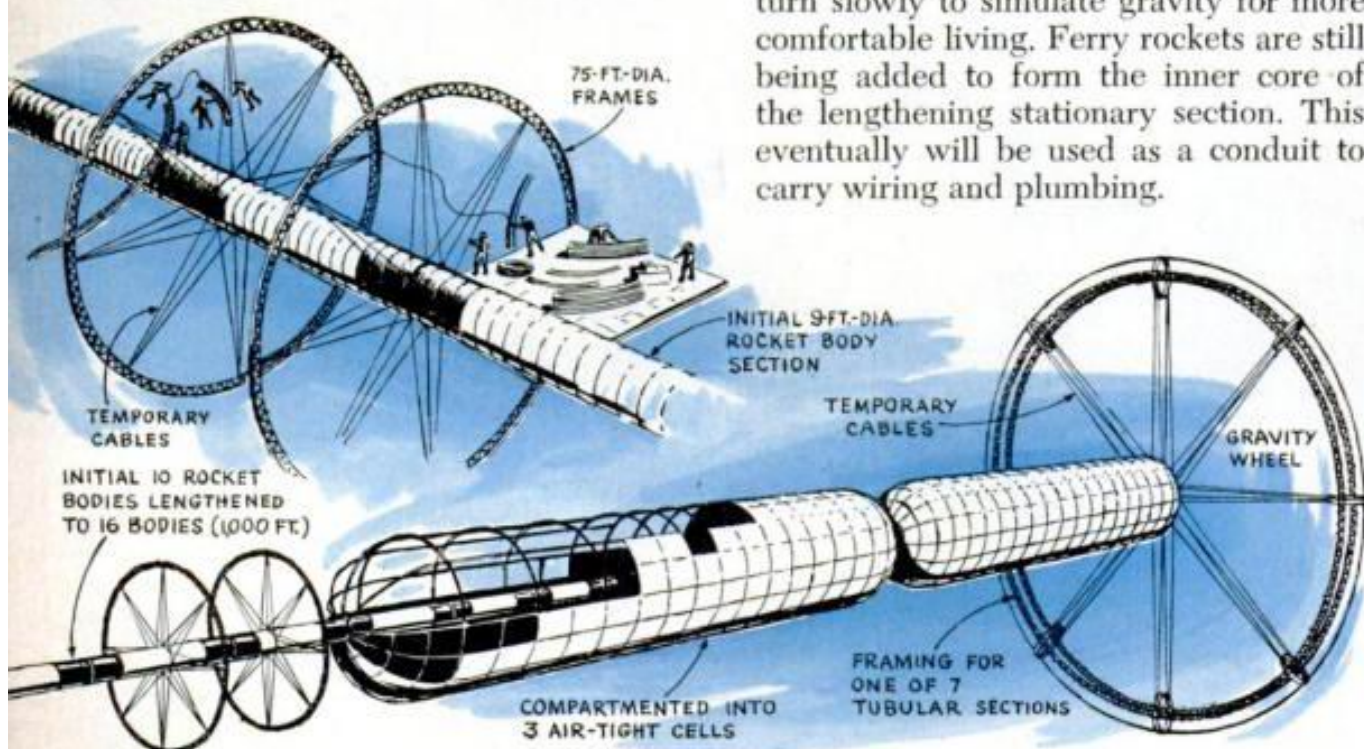


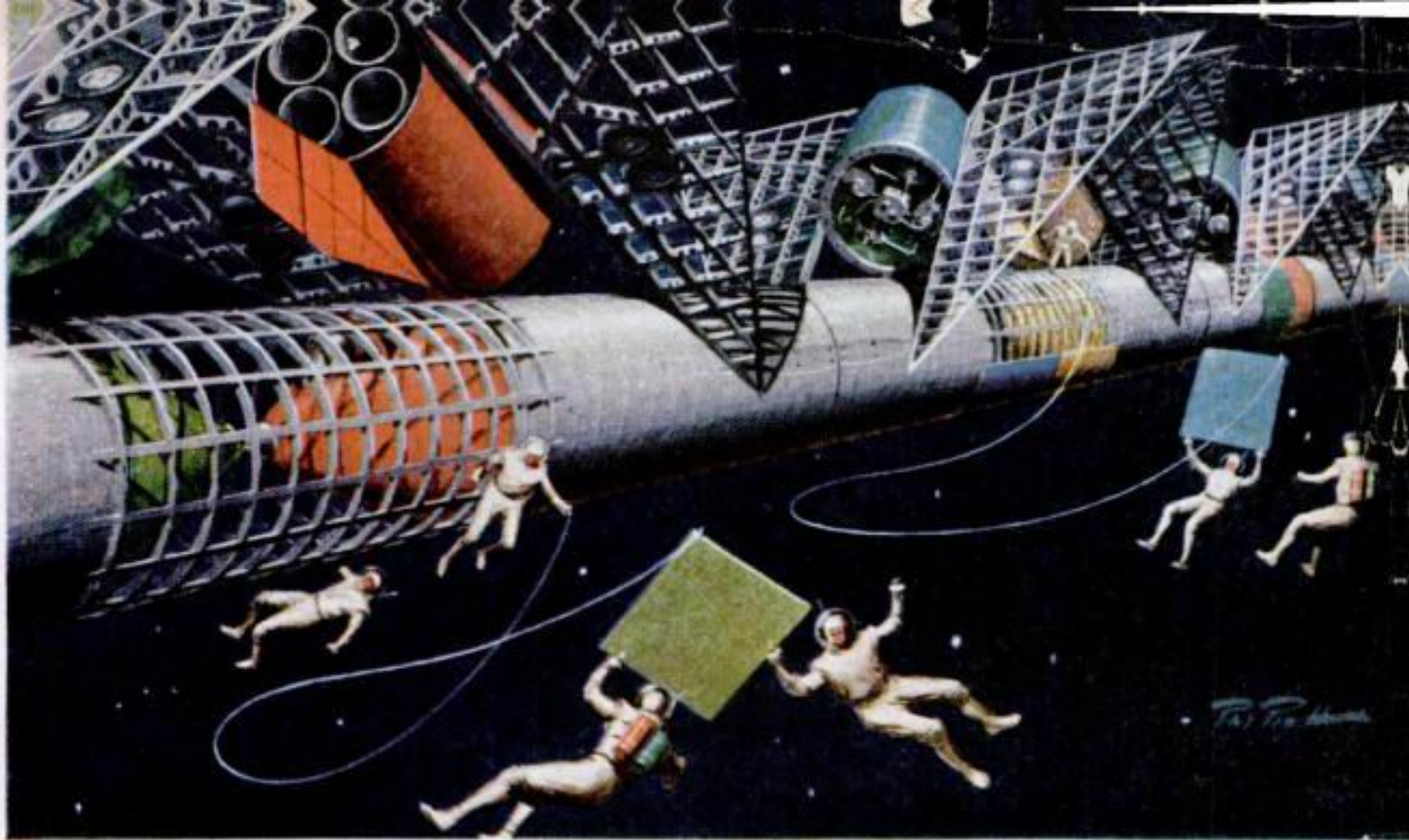
10th Day Alternate nosing together and butting of ships progresses rapidly. Here

10 have been joined and mostly skinned over, using material from wing sections,

4th Week Expansion begins as supply rockets arrive with materials, mainly pre-cut and -drilled sheet stock and formers. A series of 75-foot-diameter circular frame structures along the length of the original tube go up first. Weightlessness makes the materials easy to handle.

10th Week One cell of the expansion unit has been skinned over and is occupied by workers and scientists. Simultaneously with work on this stationary, or nonrotating, gravity-free part of the station, construction has been in progress on a wheel, 500 feet in diameter, that will turn slowly to simulate gravity for more comfortable living. Ferry rockets are still being added to form the inner core of the lengthening stationary section. This eventually will be used as a conduit to carry wiring and plumbing.



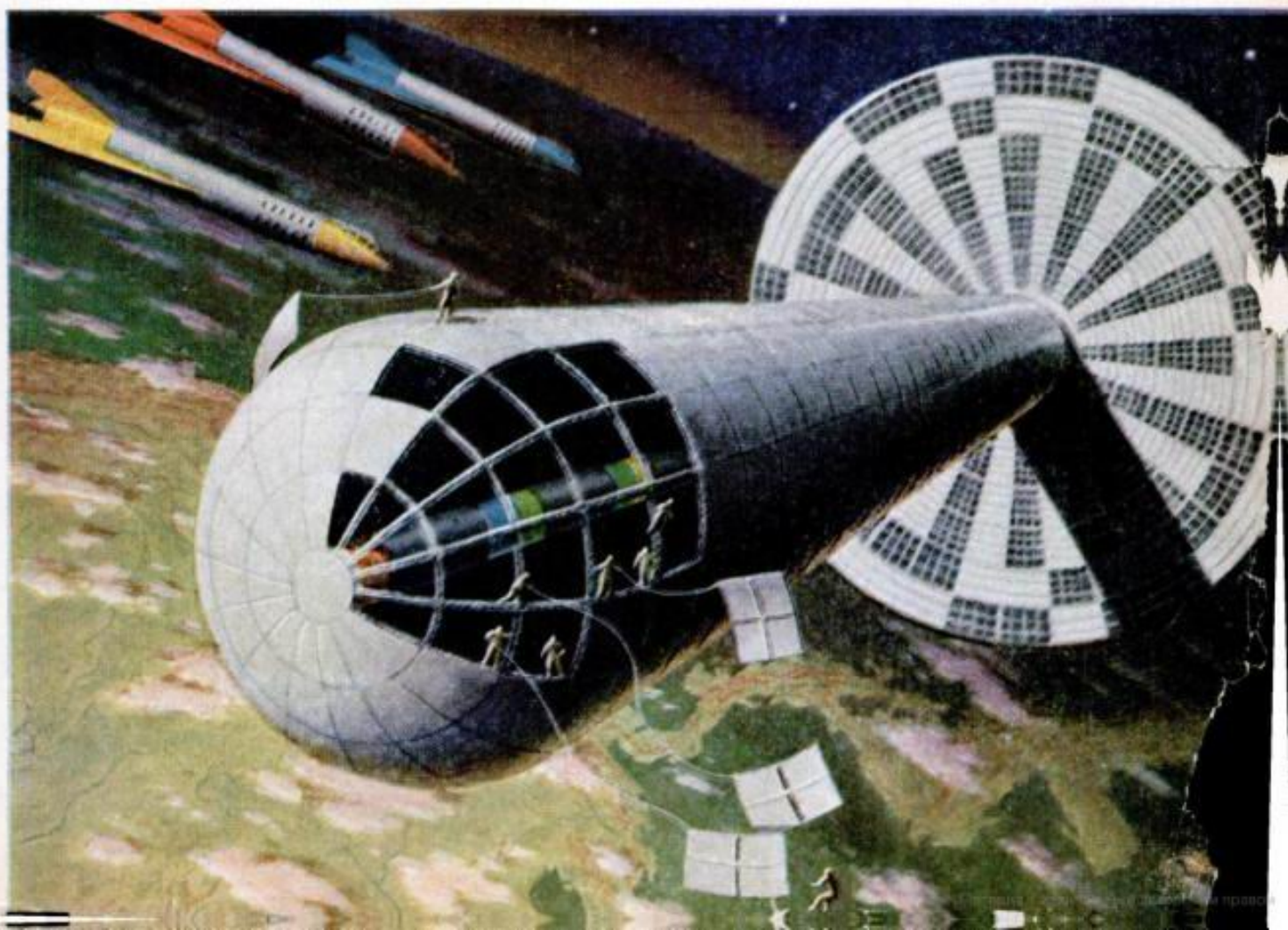


which are now bare. As front ends of two rockets are covered, noses are dismantled

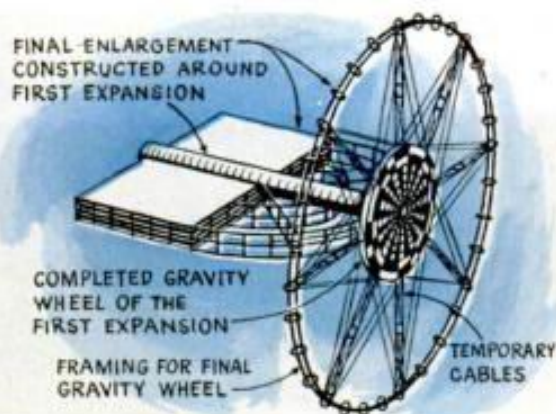
from inside. Continuous tube has compartments with pressure-lock doors.

12th Week First expansion is almost completed. Gravity wheel is finished, providing 4,000,000 cubic feet of living

space. Stationary section is about 1,000 feet long. Ferry rockets are delivering scientists and maintenance personnel.

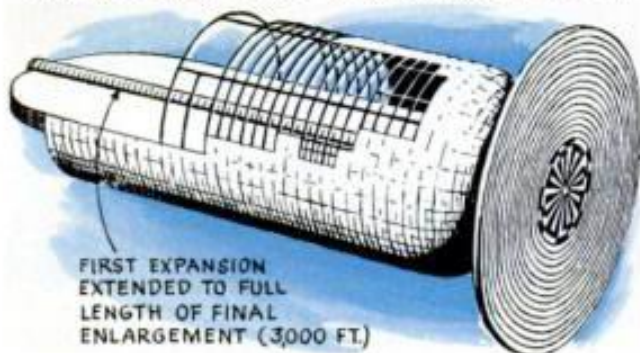


6th Month The final enlargement is under way. As the first expansion was built around basic blocks of joined ferry rockets, so the first expansion unit be-

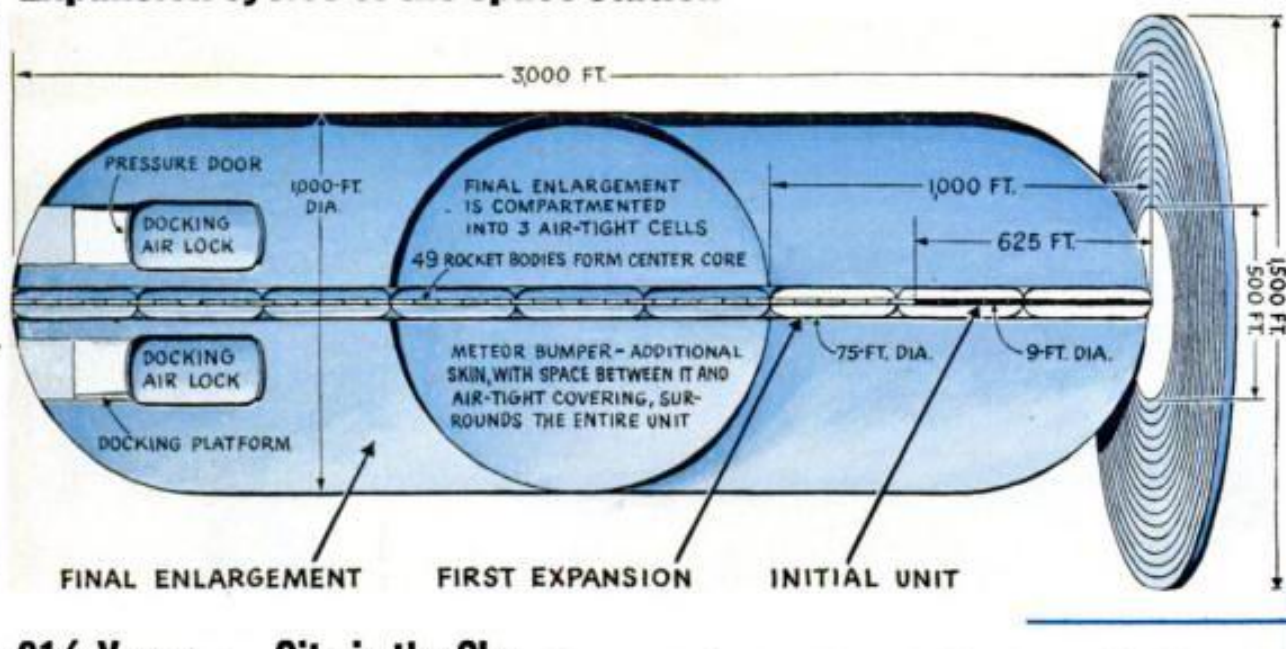


comes the foundation for this evolution from space station to space city. Framework goes up to increase the stationary section from 75 feet to 1,000 feet in diameter, that of the gravity wheel from 500 to 1,500 feet. The satellite is now fully manned and carrying on all its functions.

2nd Year Growth continues by the building-block method. Here 49 ferry rockets have been joined to form the continuous core of a stationary structure 3,000 feet long and 1,000 feet in diameter. The enlarged gravity wheel, almost a mile in circumference, is well along. Two ferry rockets a day bring construction materials from the earth. Other rockets are bringing scientific equipment, provisions for an already large space community, furnishings for comfort-of-home living. Visitors are beginning to arrive.

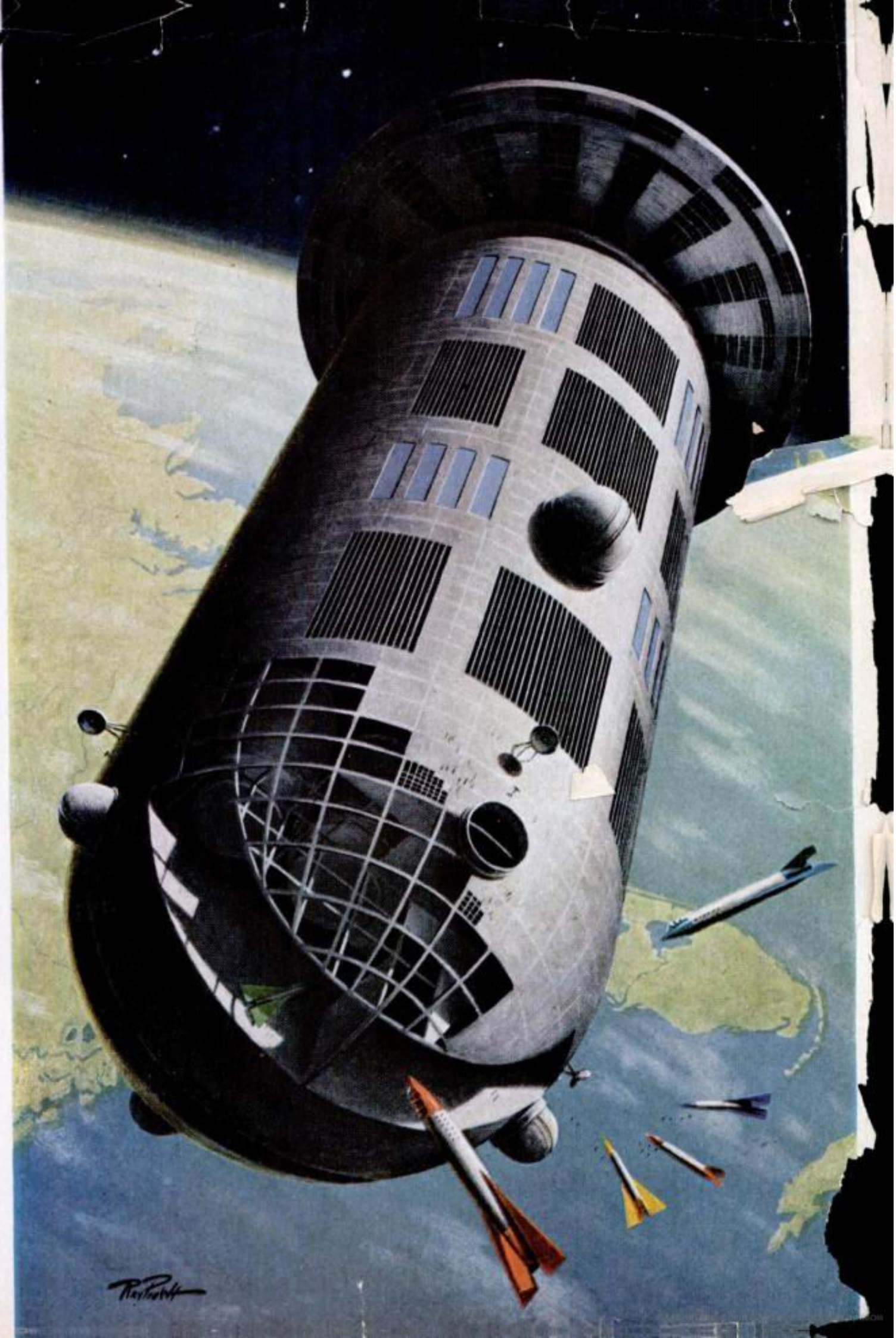


Expansion cycles of the space station



3½ Years . . . City in the Sky Ferry rockets land on the berthing deck to deliver the last loads of construction materials to the vast satellite (facing page) in which more than 20,000 people could now live and work. Two Empire State buildings, one on top of the other, with the Pentagon building rotating at one end, would make a structure far smaller. Seen exposed are observatory domes,

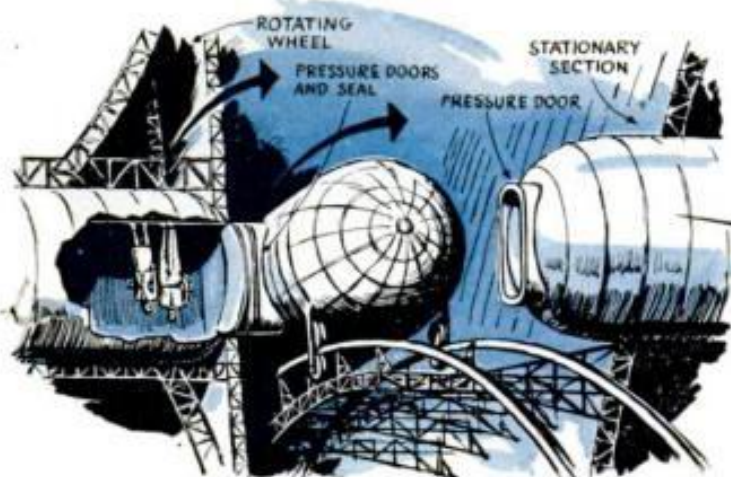
radar antennas, "venetian-blind" windows that can be adjusted to absorb or radiate solar energy for regulating inside temperatures. A thin outer skin, or meteor bumper, protects the inhabitants from direct hits by meteors. Small ones bounce off; larger ones are slowed down so that they are not likely to penetrate the main skin. (For details of the gravity wheel turn to page 98.)



GRAVITY WHEEL

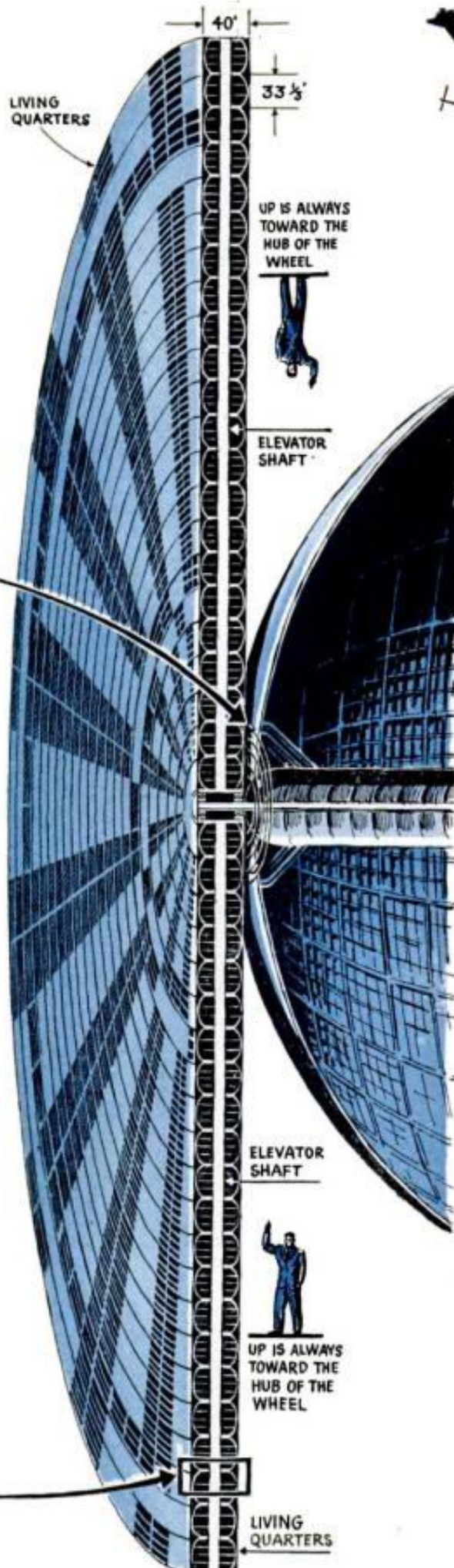


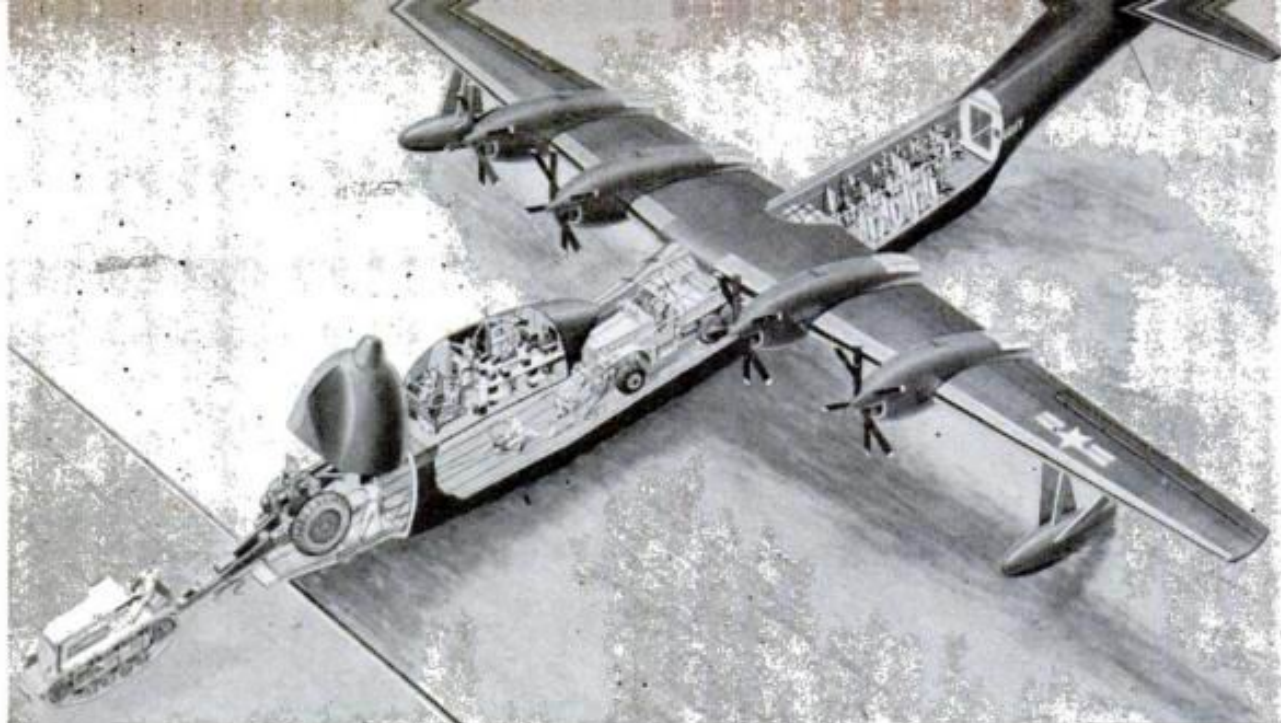
Balance of gravity wheel might be upset by unequal weight distribution such as could be caused by a gathering of people in an auditorium. Running weights up or down in shafts would counteract this (left).



Transfer of personnel from the turning wheel to the stationary section could be made by cars riding loop rails. As shown in the drawing above, a car door mates with a wheel door in a pressure seal. Passengers get aboard, the door closes, the car disconnects and goes on until it mates with a door into the stationary side. Then it stops, and a reverse pressure-seal transfer is made. Except for the pressure seals, the operation is much like that of an automatic elevator.

Living in space, with gravity adjusted to that of earth by rotation of wheel, would be normal.

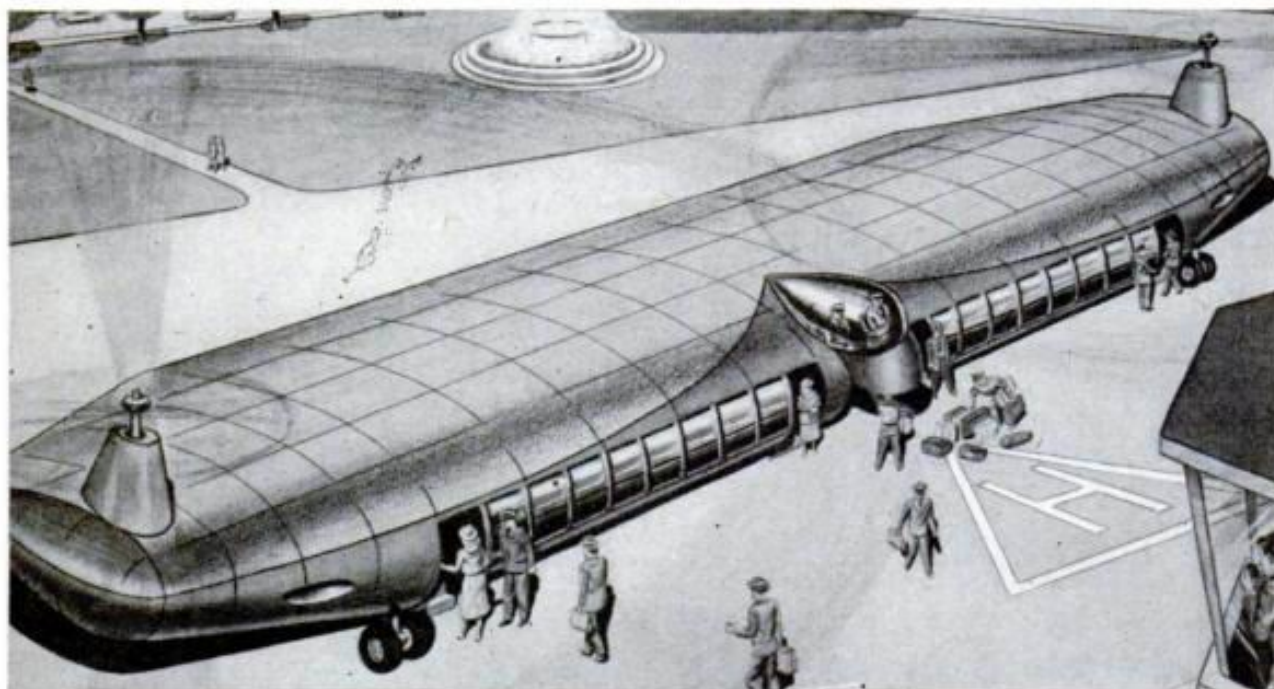




Flying LST to Land Troops, Guns on Beach

WHAT the famed water-bound LST landing ship did during World War II, this flying version can do, but hundreds of miles an hour faster. It is the R3Y-2, a nose-loading model of Convair's turboprop Trade-wind. In action, the big plane will land off-

shore and taxi to the beach. In a matter of seconds a bow ramp will be lowered to unload Marines, guns, trucks and supplies. To pull away from the beach, the pilot, sitting in an upper-deck crew compartment, will simply reverse his props and back up.

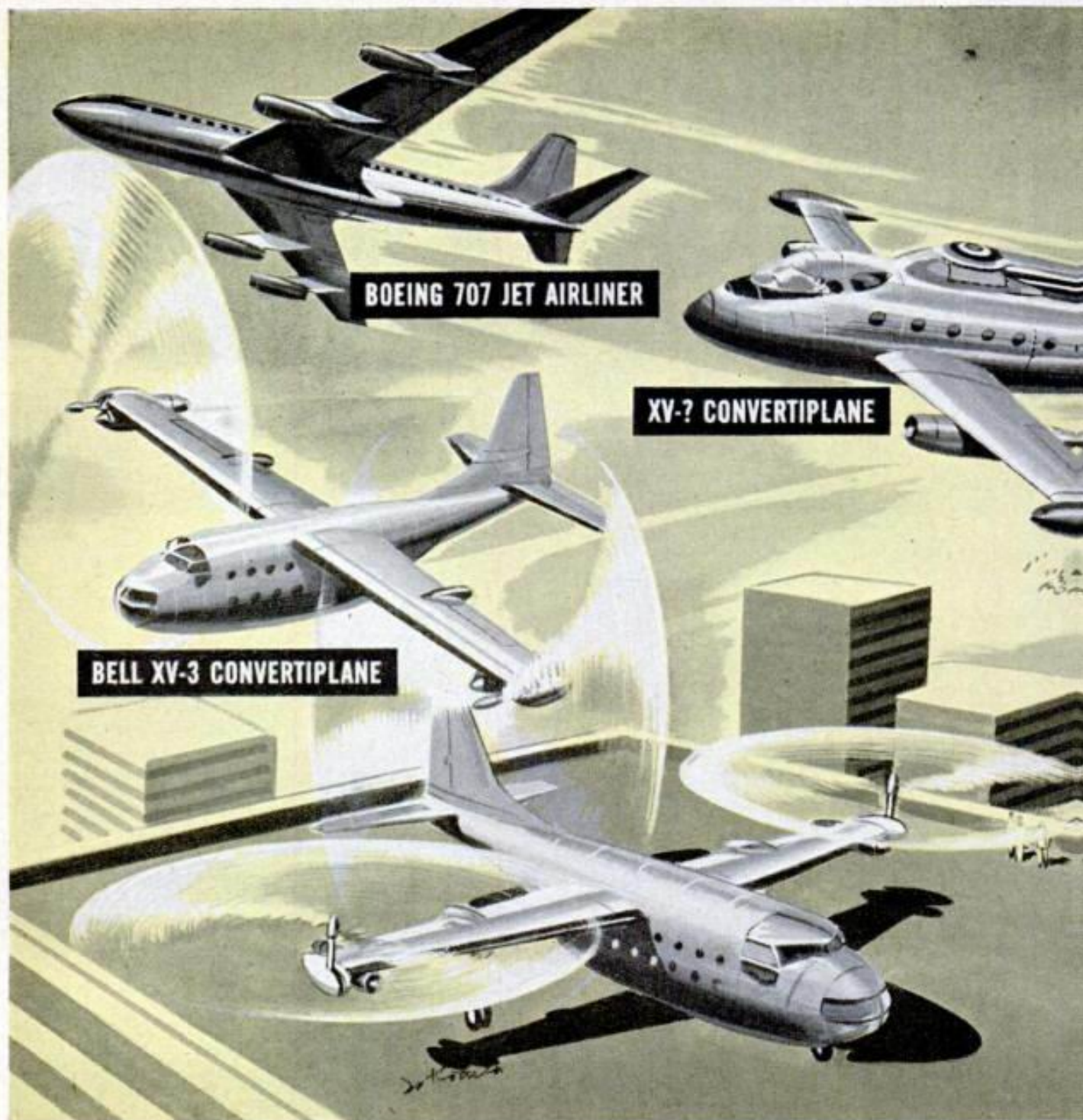


All-Wing Helicopter to Fly Sideways

A FLYING-WING passenger helicopter is the newest idea in whirlybirds. It would travel sideways instead of pointing its nose in the direction of flight.

The novel scheme was born when Bell Aircraft pilots were testing a Navy anti-submarine, tandem-rotor helicopter. During test flight, the pilots began to favor sideways

flight because "it just felt better." From there on company engineers took over and came up with the sideways-flying design shown in the drawing above. They claim that it will be more efficient, since the wing itself will supply some of the lift. Thus less power will be required from the rotors, saving fuel.



More New Planes Are Coming

ABOVE is an artist's report of dreams come true: five planes that were designers' dreams a few years ago and that you soon will see in flight—some of them this summer.

A recent sensational development is the convertiplane. Not so far back the idea was considered fantastic. Today the military has \$6,000,000 invested in these planes that take off and land like heli-

copters but convert in flight to a faster means of forward propulsion.

McDonnell XV-1 Convertiplane is the farthest along. Now being ground-tested, it is expected to fly this summer. An overhead rotor, with pressure-jet engines at the blade tips, gives it helicopter flight. A rear-of-fuselage propeller goes into action for forward flight.

Bell XV-3 Convertiplane is nearing



HORTON WINGLESS

MCDONNELL XV-1 CONVERTIPLANE

completion. Wing-tip propellers pointing upward serve as helicopter rotors. In forward flight, stubby wings carry the lift as the "rotors" tilt 90 degrees forward to become true propellers.

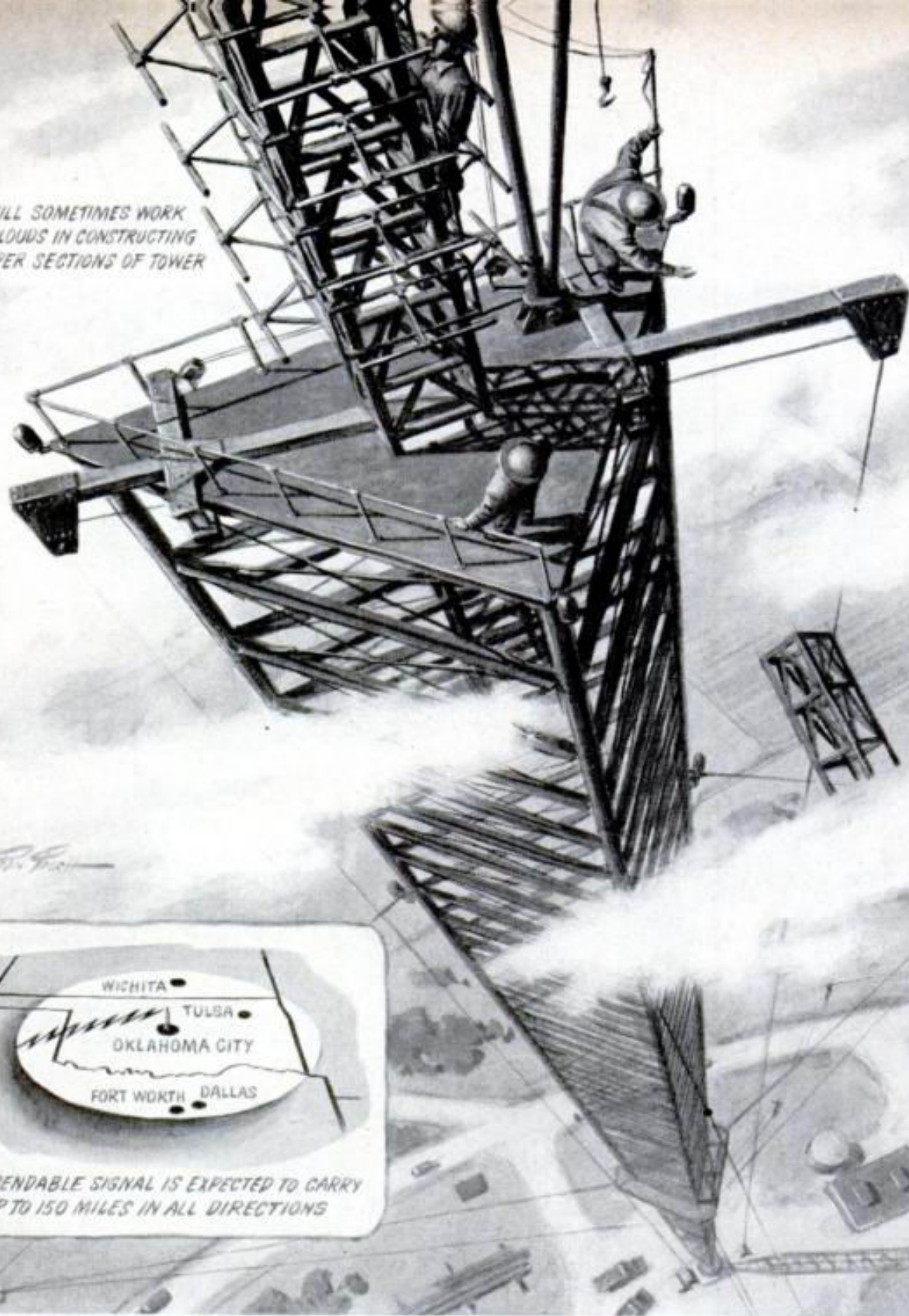
XV-? Convertiplane is the artist's idea of what the Sikorsky job, still on the drawing boards, may look like. As shown here, overhead rotors, used for helicopter performance, fold up and retract into the fuselage in flight as gas-turbine engines speed it forward.

Boeing 707 Jet Airliner, expected to

fly in August, may be America's answer to the British Comet. The huge jet will carry from 80 to 150 passengers nonstop across the continent (five hours) or from New York to London (seven hours). Cruising speed will be 550 m.p.h.

Horton Wingless is all fuselage—or all wing, if you prefer. At present it is planned as a 10-place executive plane for economical nonstop transcontinental flight at 300 m.p.h. Its designer foresees a mammoth 4,000-troop military version.—*Herbert O. Johansen.*

MEN WILL SOMETIMES WORK
ABOVE CLOUDS IN CONSTRUCTING
UPPER SECTIONS OF TOWER



DEPENDABLE SIGNAL IS EXPECTED TO CARRY
UP TO 150 MILES IN ALL DIRECTIONS

Man's Tallest Tower to Broadcast TV

THE highest structure ever attempted by man is climbing skyward from the Oklahoma plains. A hundred feet taller than the world's tallest building, it will be used to broadcast television programs beginning next July.

KWTV, Oklahoma City, wants a lot of height to boost reception range. It's taking some doing to achieve it.

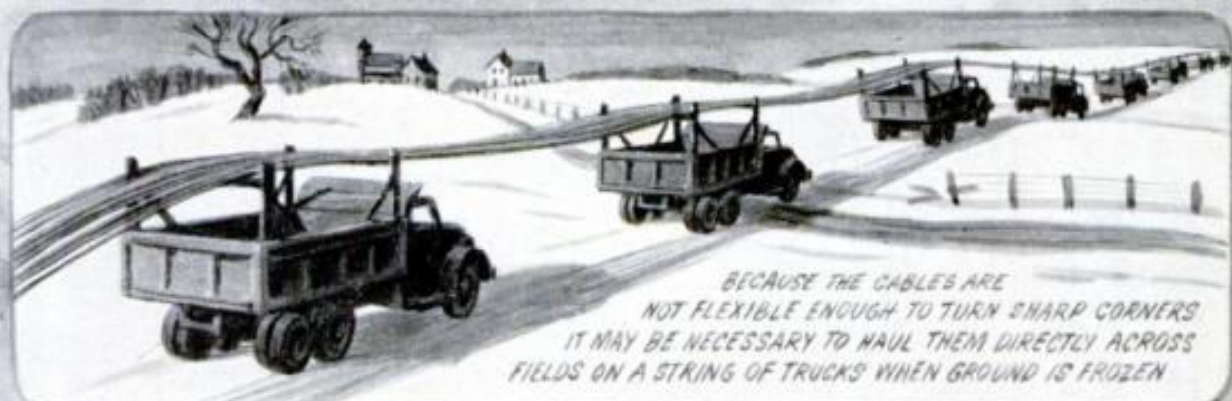
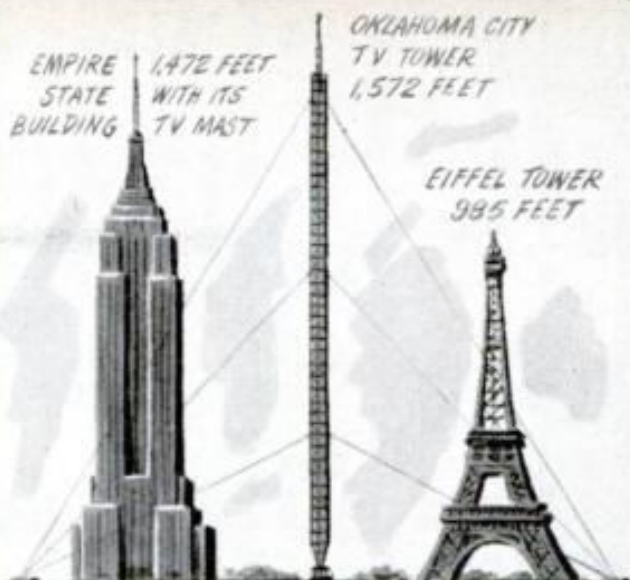


THE TOWER WILL HAVE A ONE-MAN ELEVATOR RUNNING TO THE 1,340-FOOT LEVEL

EMPIRE STATE BUILDING 1,472 FEET WITH ITS TV MAST

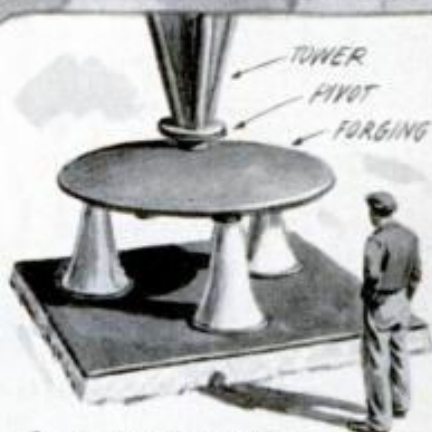
OKLAHOMA CITY TV TOWER 1,572 FEET

EFFEL TOWER 985 FEET



BECAUSE THE CABLES ARE NOT FLEXIBLE ENOUGH TO TURN SHARP CORNERS IT MAY BE NECESSARY TO HAUL THEM DIRECTLY ACROSS FIELDS ON A STRING OF TRUCKS WHEN GROUND IS FROZEN

ENGINEERS AND FOREMEN WILL LIE ON HOSPITAL-TYPE BEDS TO WATCH CONSTRUCTION OF TOP SECTIONS THROUGH FIELD GLASSES, USING TELEPHONE AND RADIO TO DIRECT WORKERS



TOWER WILL PIVOT ON AN EIGHT-FOOT FORGING, PERMITTING IT TO TWIST WITH THE WIND

The tower is triangular in cross section, 12 feet on a side. The three legs are solid steel cylinders eight inches through.

Nine guy wires bracing the tower are as much as $4\frac{1}{4}$ inches in diameter—as thick as the cables on some suspension bridges—to protect it from high winds. They will be anchored in steel and concrete 900 feet from the base.

Four coaxial cables running up to the antenna are $6\frac{1}{4}$ inches in diameter. And each ponderous 20-foot section weighs 1,600 pounds.

The tower alone will cost more than a half-million dollars. It will radiate 316,000 watts, or upward of 50,000 watts more than the next most powerful TV station in the United States.

END



ESCAPING
RADIOACTIVE
STEAM

INSTRUMENT
TRAILERS

ELEVATOR
SHAFT

RADIATION SAFETY
CHECKPOINT

POWER MEASURING EXPERIMENT

RADIOISOTOPE
RECOVERY
EXPERIMENT

RADIOISOTOPE
SAMPLER

STORAGE TANK

CONDENSERS
POWER
MEASURING
INSTRUMENTS

STEAM LINE

TANKS FOR DRILLING FLUID

HOLE FOR
RECOVERING
STEAM

HOLE FOR
RECOVERING
RADIOISOTOPES
AND INJECTING
WATER FOR STEAM

NEUTRON
EXPERIMENTS

BLAST DOOR

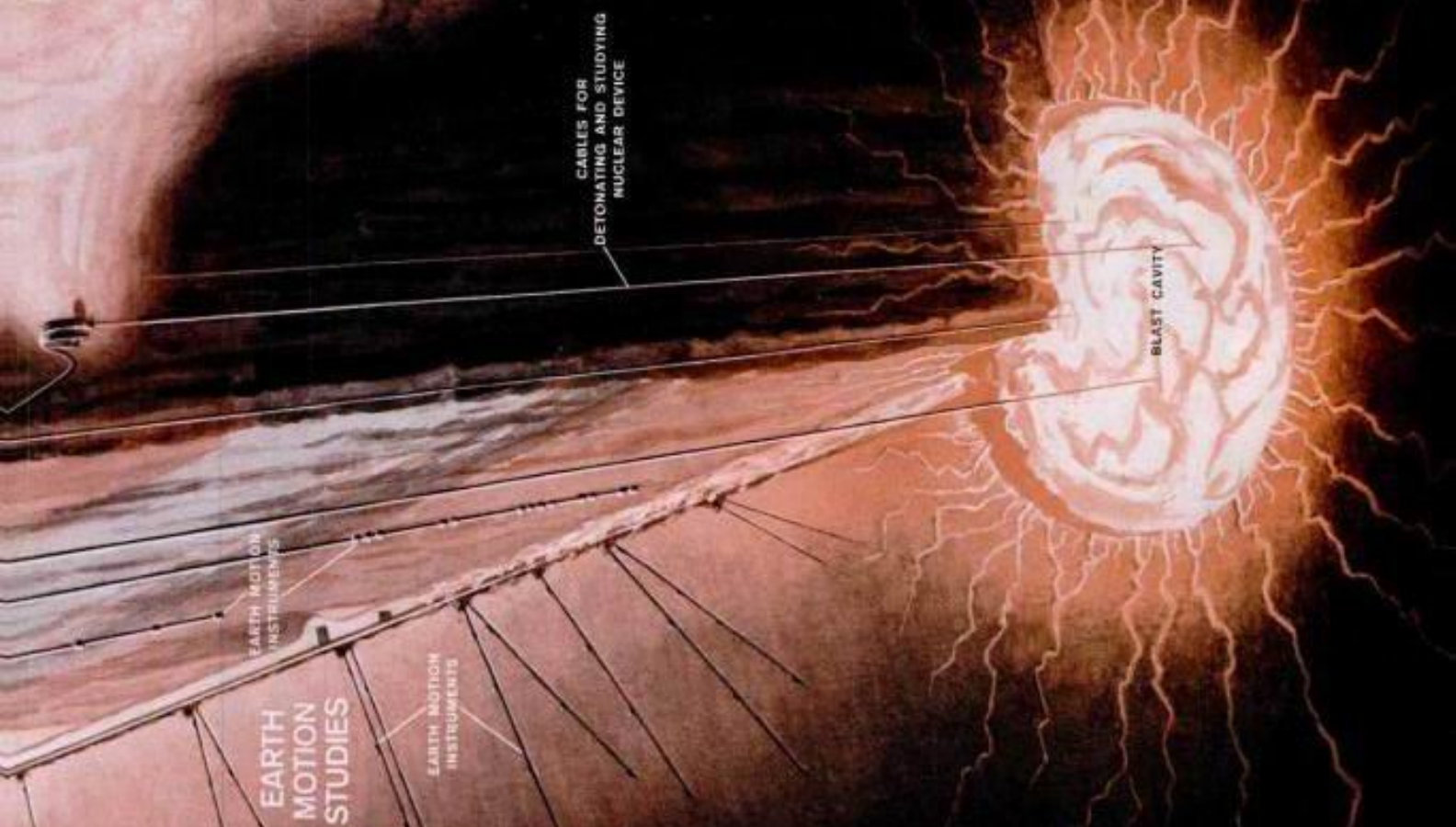
CONCRETE-BLOCK BARRIER

An A-Blast Harnesses for Peaceful Test

Last week U.S. scientists were mulling over results of the first trial blast—Project Gnome—in an ambitious program to harness nuclear explosions for peaceful purposes. The AEC program, called Plowshare, is seeking ways to use A-bombs and H-bombs to build harbors, extract oil from shale, tap new water supplies, provide new power sources. The Project Gnome experiment encompassed everything from basic studies of neutron effects to tests aimed at the practical use of power from steam.

In this drawing the Gnome site near Carlsbad, N. Mex., is partially cut away to a depth of 1,200 feet to show the 110-foot blast cavity, the 1,100-foot-long horizontal tunnel (now partially collapsed) that connects the cavity with the elevator shaft, and six vertical holes drilled deep into the rock. These made possible four major experiments (indicated in larger type): 1) NEUTRON EXPERIMENTS. Rapidly rotating wheels with samples of various elements were placed at the far end of the tunnel to be bombarded by neutrons speeding from the blast. 2) EARTH MOTION. Dozens of instruments were placed in holes and on the surface to record the earth's complex heavings. Meanwhile seismic stations around the world recorded the tremor. 3) RADIOISOTOPE RECOVERY. A sampler collected radioisotopes (radioactive elements) from the blast. Later a rig drilled for more extensive samples. 4) POWER MEASURING. Water injected into the blast cavity will be turned into steam by the 1,440°F. heat trapped there. After its energy is measured, the steam will be condensed and stored.

But one major thing went wrong with Gnome. Radioactive steam escaped, no one knows how, up the elevator shaft and past three barriers—the sealed-off tunnel, the concrete block barrier and a blast door. There must have been a leak in the cavity, which may have to be plugged before the steam power experiment can proceed.



The Most Complicated Building Ever Built

Pan Am's high-speed elevators will zip from railroad tracks under it to a copter-port roof

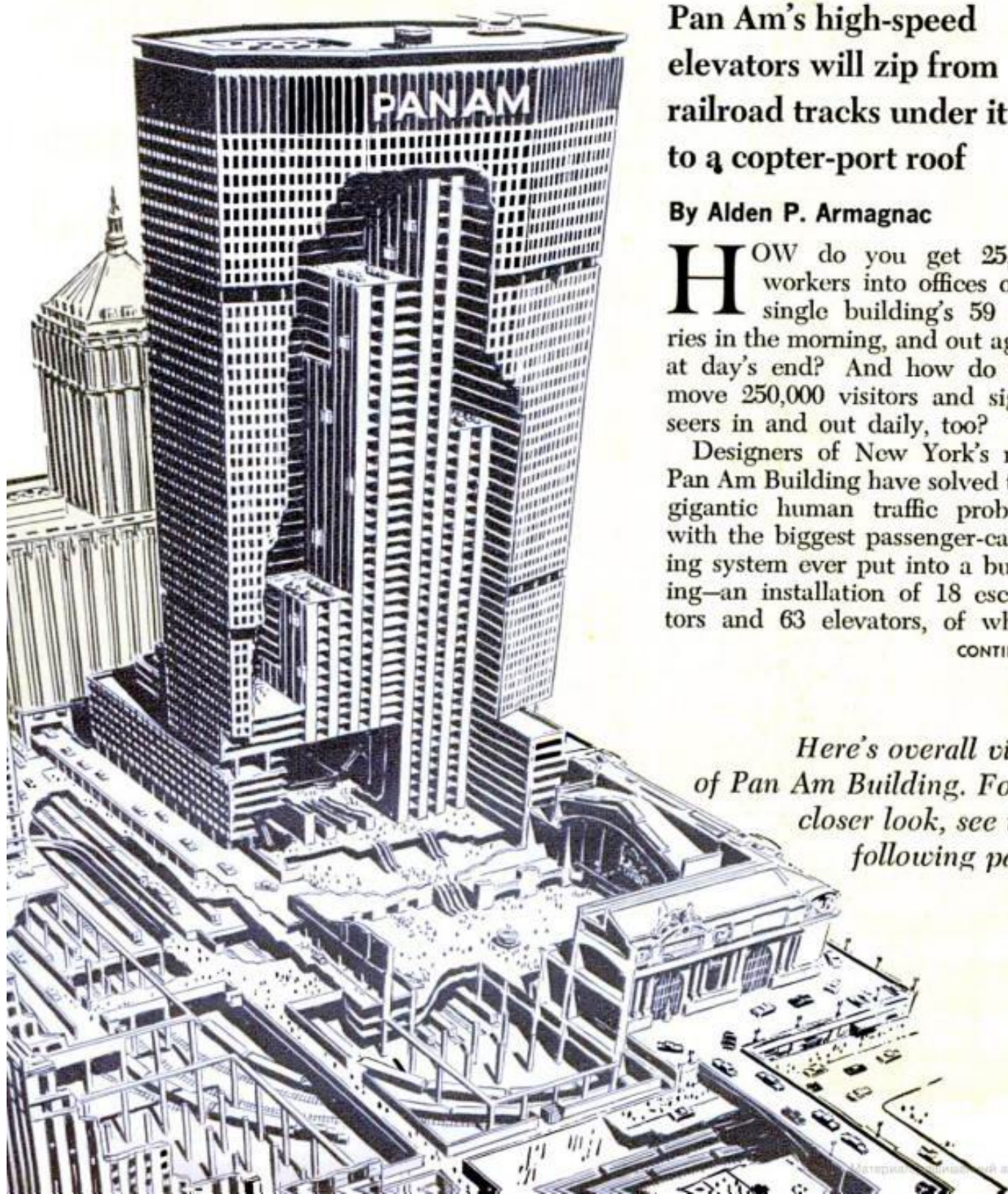
By Alden P. Armagnac

HOW do you get 25,000 workers into offices on a single building's 59 stories in the morning, and out again at day's end? And how do you move 250,000 visitors and sightseers in and out daily, too?

Designers of New York's new Pan Am Building have solved that gigantic human traffic problem with the biggest passenger-carrying system ever put into a building—an installation of 18 escalators and 63 elevators, of which

CONTINUED

Here's overall view of Pan Am Building. For a closer look, see the following page





TV cameras in walls and ceilings stand guard over people on escalators. Should anyone fall, monitor screen instantly alerts control center

lators, serving west and north street-level entrances, link the street, second, and third floors of the three-story lobby. The Pan Am's escalators will be able to carry about 50,000 people an hour.

Banks of automatic elevators will

to stop escalator. Cameras also aid in varying escalators' up-or-down patterns to suit flow of human traffic at different times of day.

speed up to 20,000 people an hour to and from the higher floors. Six elevators will run to the top floor at more than 1,600 feet a minute, or 18 m.p.h.

Offbeat time clocks. Slightly staggered office hours will spread out workers' arrival and departure times. With that much help, the capacity of the speedy escalators and elevators is expected to avert traffic jams at nine and five. Three restaurants within the building will ease the lunch-time rush to eating places outside.

Taxicabs and private cars, swinging off an elevated section of Park Avenue, will unload and pick up passengers at second-floor entrances to the building. Motorists may park cars in a 400-car multi-level garage, starting at the second floor, in the building's southeast corner.

Having provided for people coming by road, by train, and afoot, the designers went on to anticipate arrivals by air. The Pan Am's flat roof has been given the needed structural bracing to serve

[\[Continued on page 216\]](#)



Proposed helicopter port on Pan Am Building's rooftop would be New York's first airport in heart of city. First helicopter test flights from roof have been scheduled for fall of '63.

New York
General Bldg.

CORNUCOPIA
TOWER

PAN AM BUILDING

10-STORY
BASE

ELEVATORS
for lower
stories

THIRD FLOOR

Elevated
extension
of Park Ave.

ESCALATORS
for north
entrance

ESCALATOR
to 3rd floor

Vanderbilt Ave.

STREET AND
2ND-FLOOR
ENTRANCES

CONTROL
CENTER

ESCALATORS
for west
entrance

TOWER
ELEVATORS
(8 banks)

STREET FLOOR

TRAIN
GATES

TO
400-CAR
GARAGE

R.R. TRACKS
AND PLATFORMS
(upper level)

UNDERGROUND
PASSAGEWAY

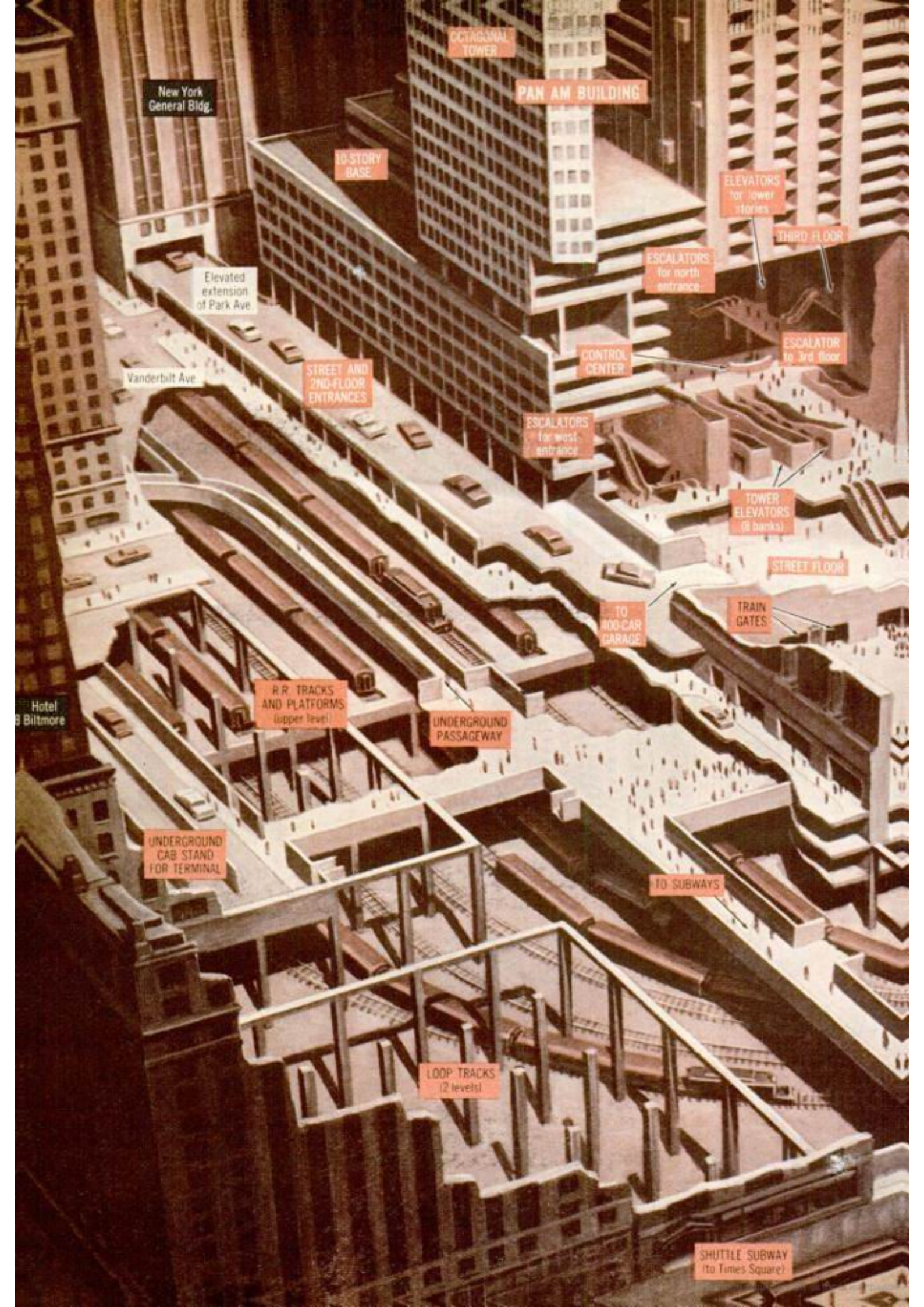
UNDERGROUND
CAB STAND
FOR TERMINAL

TO SUBWAYS

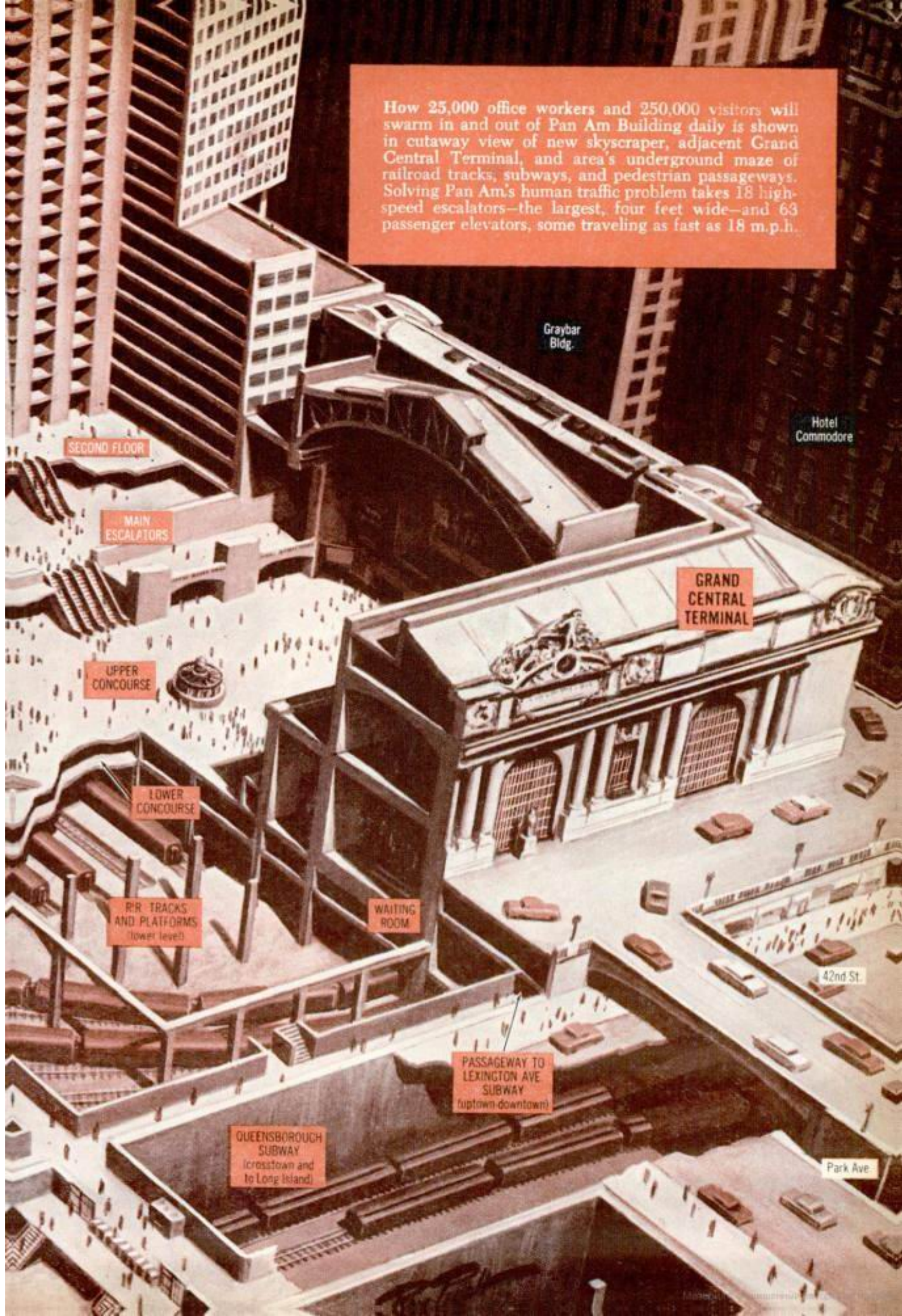
LOOP TRACKS
(2 levels)

SHUTTLE SUBWAY
(to Times Square)

Hotel
Biltmore



How 25,000 office workers and 250,000 visitors will swarm in and out of Pan Am Building daily is shown in cutaway view of new skyscraper, adjacent Grand Central Terminal, and area's underground maze of railroad tracks, subways, and pedestrian passageways. Solving Pan Am's human traffic problem takes 18 high-speed escalators—the largest, four feet wide—and 63 passenger elevators, some traveling as fast as 18 m.p.h.



Graybar
Bldg.

Hotel
Commodore

SECOND FLOOR

MAIN
ESCALATORS

GRAND
CENTRAL
TERMINAL

UPPER
CONCOURSE

LOWER
CONCOURSE

RR TRACKS
AND PLATFORMS
(lower level)

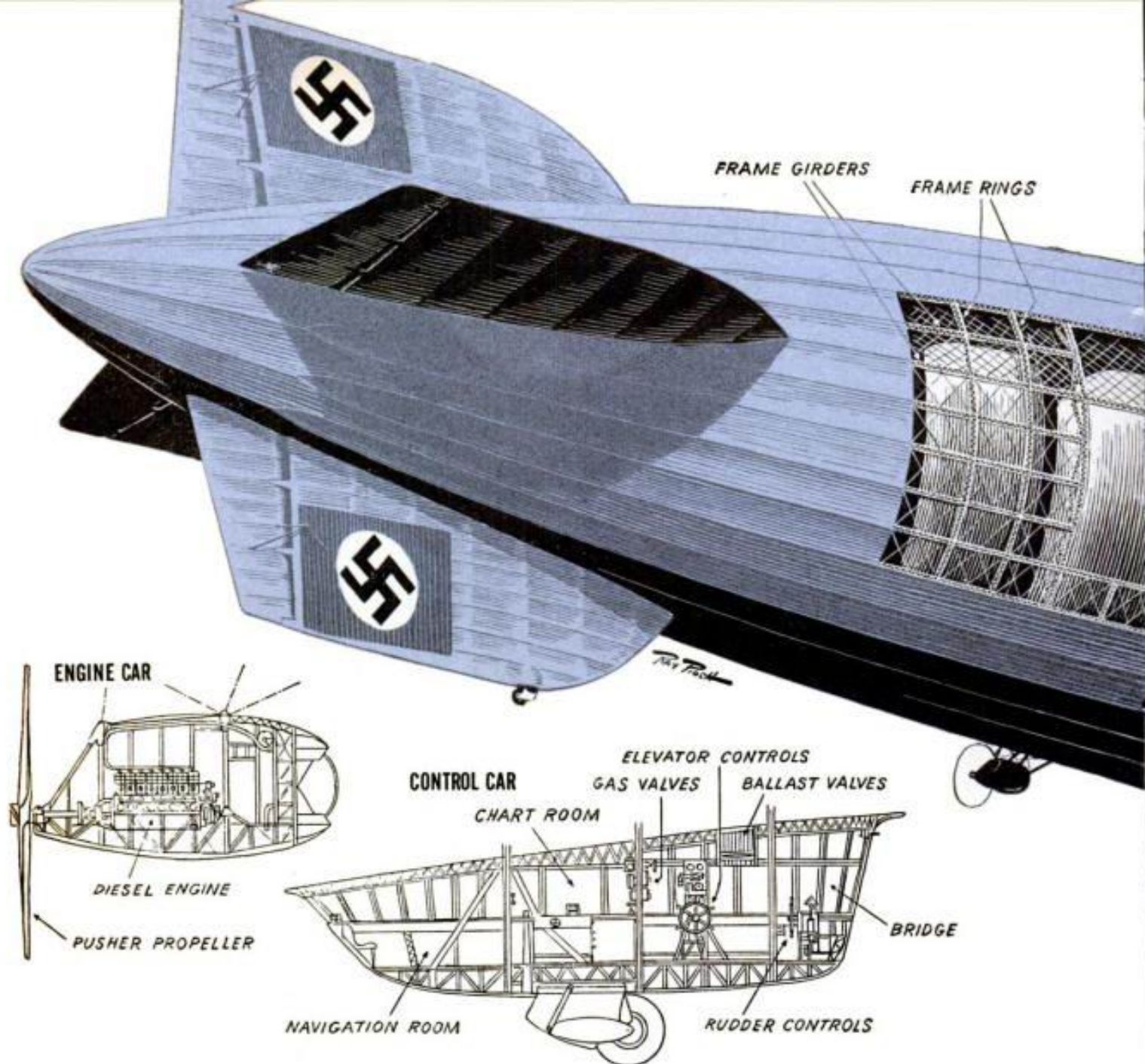
WAITING
ROOM

PASSAGEWAY TO
LEXINGTON AVE
SUBWAY
(uptown-downtown)

QUEENSBOROUGH
SUBWAY
(crosstown and
to Long Island)

42nd St.

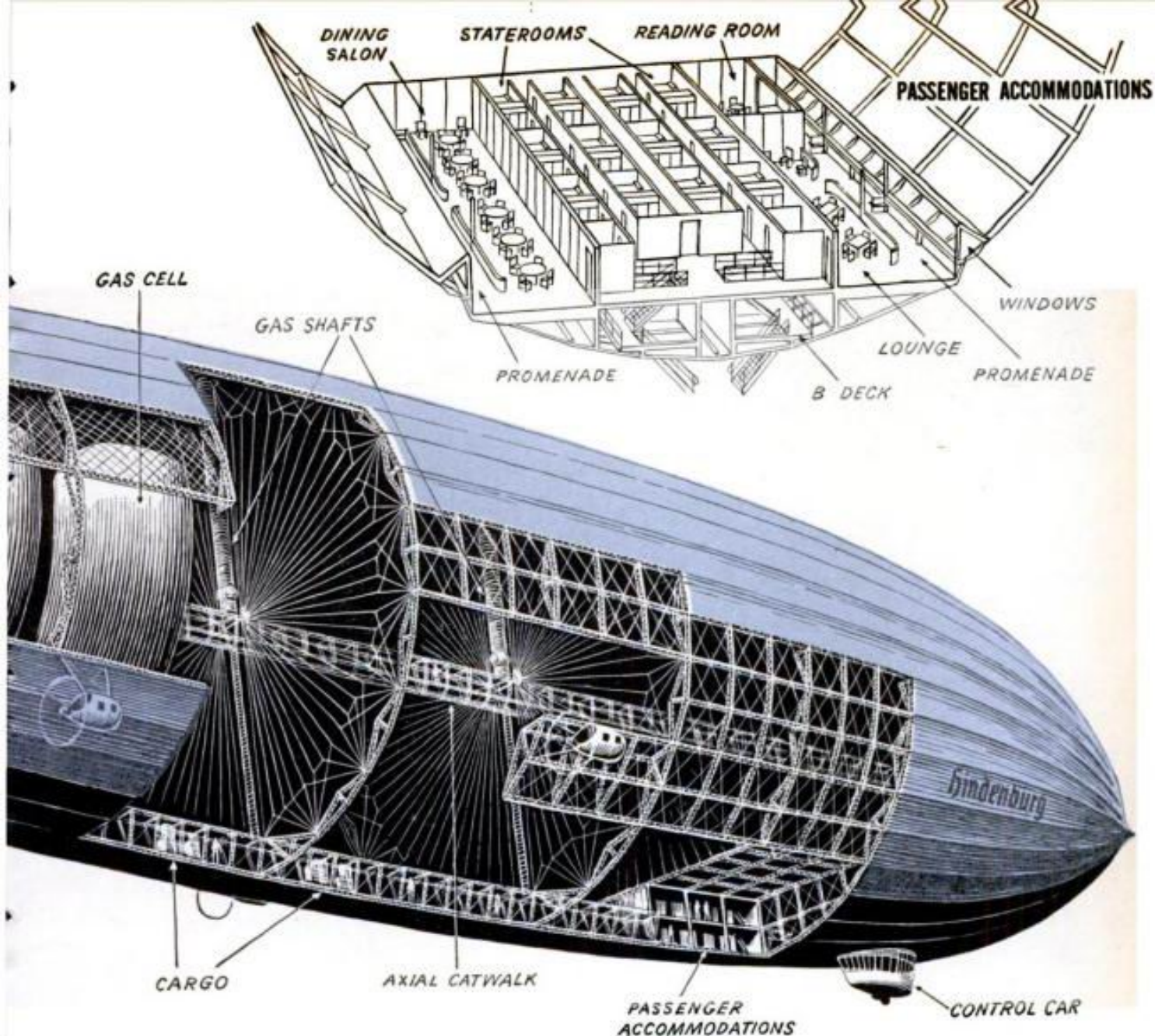
Park Ave.



graduated in size from the fat middle to the pointed bow and stern. Holding the rings were 35 flat girders running lengthwise, and an interlocking cobweb of steel wires. It took 5,500,000 rivets just to fasten the rings to the girders.

The Hindenburg was fatter across her midsection than previous Zeppelins—the Shenandoah had snapped in two, indicating the need for strength amidships. But the heftiest framework supported the bow, for it hooked onto the mooring mast and had to hold, no matter how gusty the conditions on the ground.

This giant craft did not fly like a bird or an airplane. It floated in the air. The buoyancy came from 16 separate gas cells—tremendous bags that were shaped like gigantic pairs of pants. From below you saw only the floppy “pants legs.” These gas cells pushed up against the “ceiling” of the airship (a rope net kept cells from chafing against the hull).



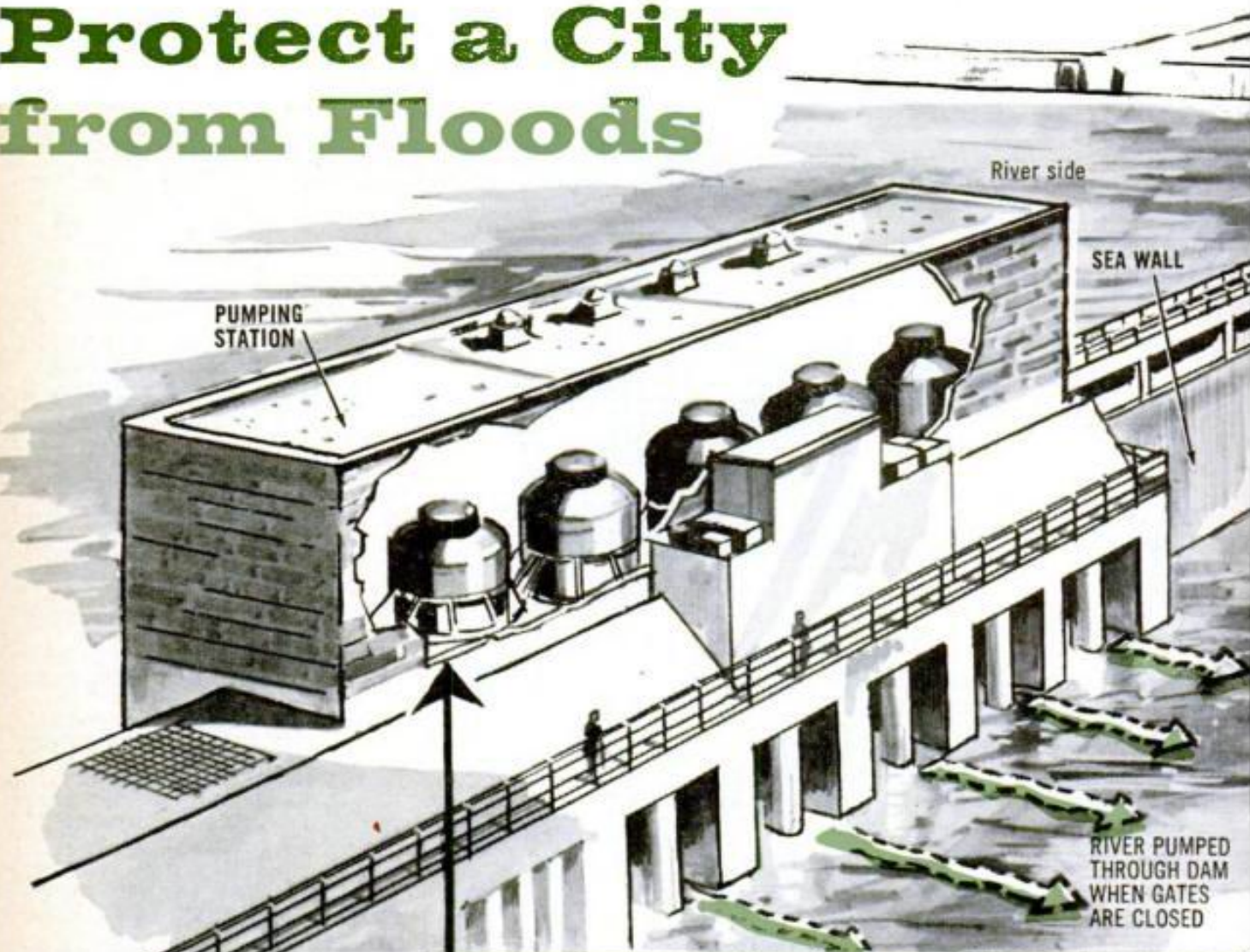
Your tour guide would avoid mentioning it, but those gas cells contained 7,000,000 cubic feet of hydrogen, the lightest gas known—and also the most powerfully explosive. U. S. airships used helium, not quite so buoyant but not at all inflammable. Germany had no helium. Already the black clouds of World War II loomed, and Americans were in no mood to supply rare strategic material to a future enemy.

The Hindenburg's designers understood the danger. Chimneylike *Gasschächte* (shafts) vented any seeping hydrogen to the outside of the hull. You caught sight of riggers, wearing buttonless asbestos suits and felt-soled shoes to avoid any chance of static sparks, inspecting those shafts. They also checked the gas cells—they walked right through them along the *Mittellaufgang*, the hull-bracing axial catwalk that pierced the cells by way of little canvas tunnels.

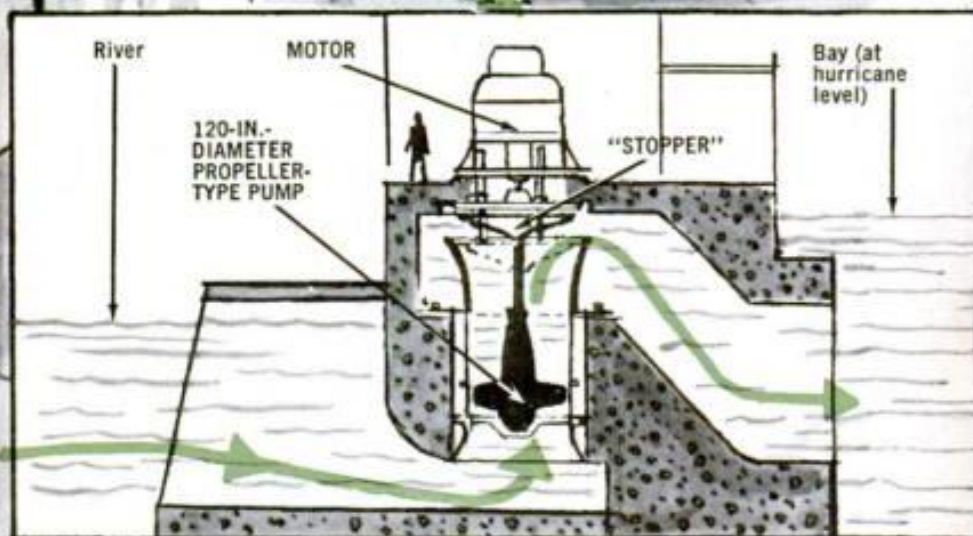
Walking aft past the officers quarters, you came to the

CONTINUED

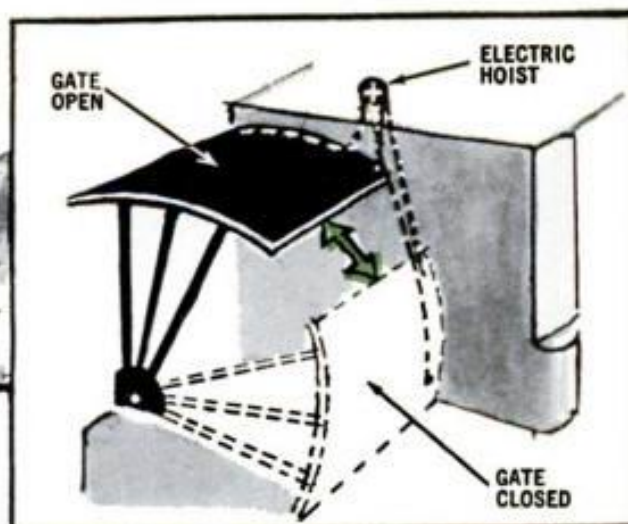
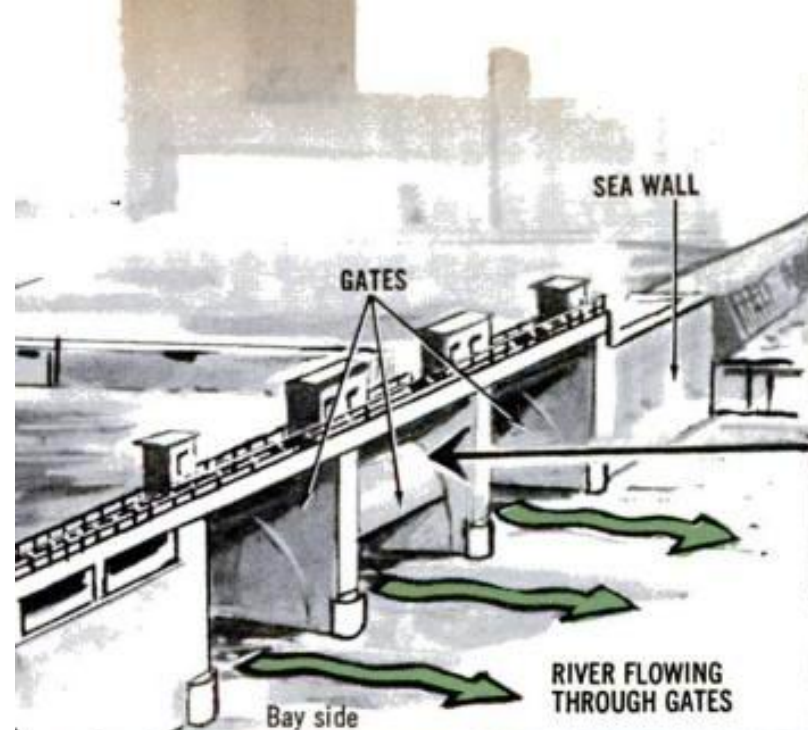
Hurricane Dam to Protect a City from Floods



DOWNSTREAM FACE of hurricane dam is pictured with gates open to let river through. To hold back a hurricane tide, gates close—and whole river is pumped through dam into bay, by pumping station in foreground, until the abnormal tide recedes.

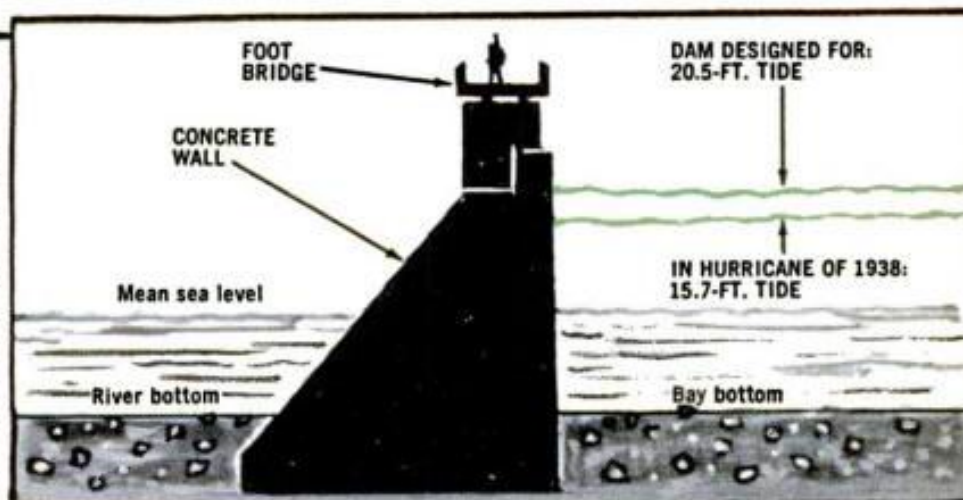


BIGGEST IN THE WORLD, five pumps like this one can pump river "uphill" against head of 20-foot hurricane tide, exceeding worst in modern times. Hydraulically operated "stoppers" could close outlets against sea in unlikely event of a still-higher tide.



THREE GATES like this, in usual raised position, give 25-foot vertical clearance for river craft. Lowered for hurricane (dotted outline), the gates seal the 40-foot-wide openings.

CONCRETE SEA WALL has this shape. Atop is foot bridge between pumping station and river gates. Markings compare highest sea of modern times, 15.7 feet above mean sea level in 1938 hurricane, and 20½-foot rise for which dam is designed. Six-foot rise was enough to begin damage to city.



A sea wall, gates, and pumps that swallow up a whole river will save Providence from inundation by gale-whipped seas

By Alden P. Armagnac

WHEN hurricane winds push the sea as high as 15 feet above its normal level, hardest-hit of any northeastern U. S. city is Providence, R. I. The city's low-lying downtown area, straddling the tidal Providence River, has been flooded three times in 25 years—with damage that would total \$75,000,000 at current prices. Soon, however, the disastrous floods will be ended, by the country's first hurricane dam.

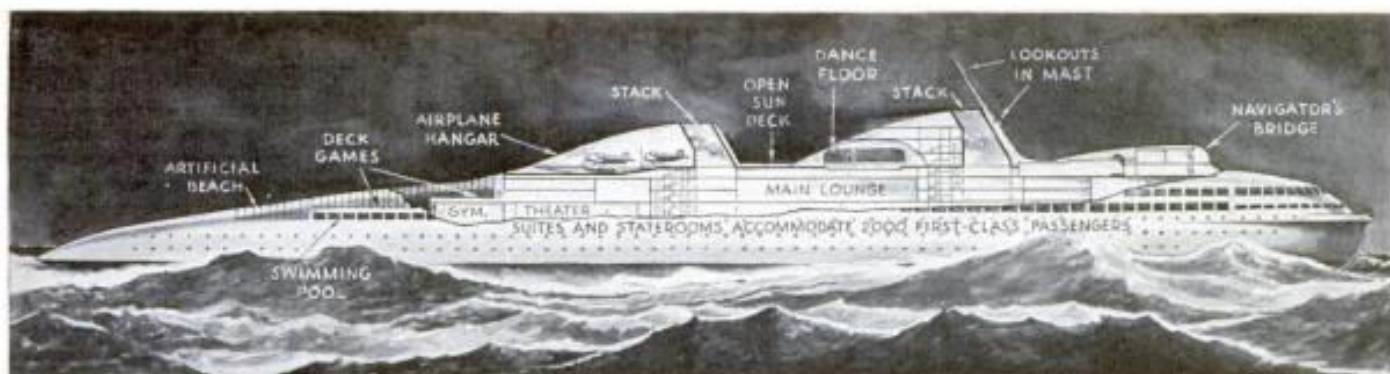
Now under construction across the river's mouth, the 680-foot-long dam combines a concrete sea wall, river gates, and a mighty pumping station.

Rising 25 feet from its normal water

line, the sea wall is designed to fend off a hurricane tide reaching a phenomenal height of 20½ feet above mean sea level as it funnels up Narragansett Bay.

Gates at three openings in this barrier will usually be raised—allowing the river to flow through, and small craft to pass. At a hurricane's onset, lowering the gates will seal the wall.

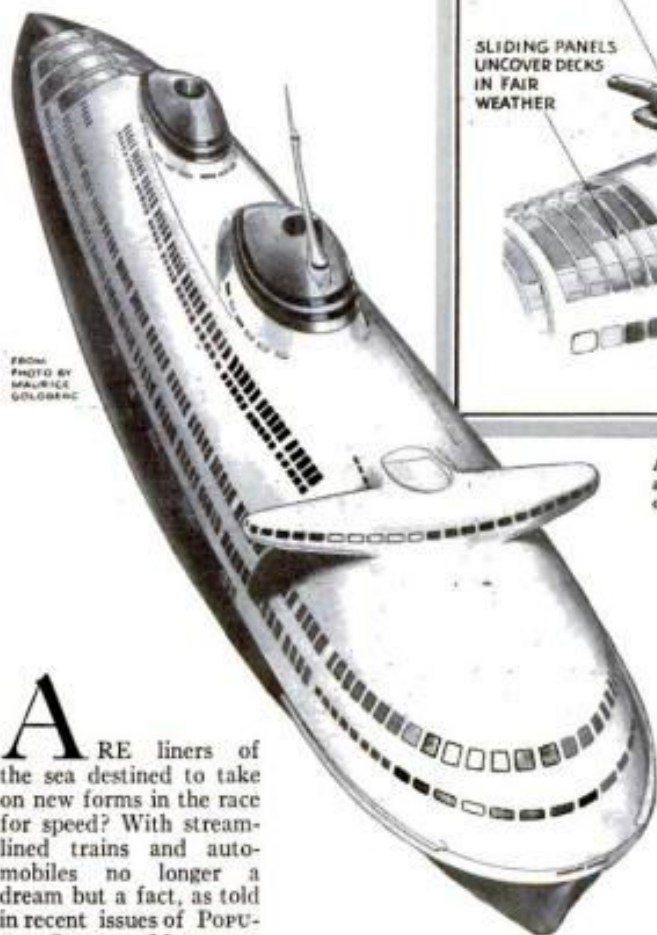
Pulling the cork. How about the bottled-up river, which keeps right on coming? The answer is to pump the whole river through the dam, with the built-in pumping station. That amounts to propelling the river uphill, against the "head" or back pressure of the sea's higher level. Five gigantic electric pumps, the world's biggest, will discharge the re-



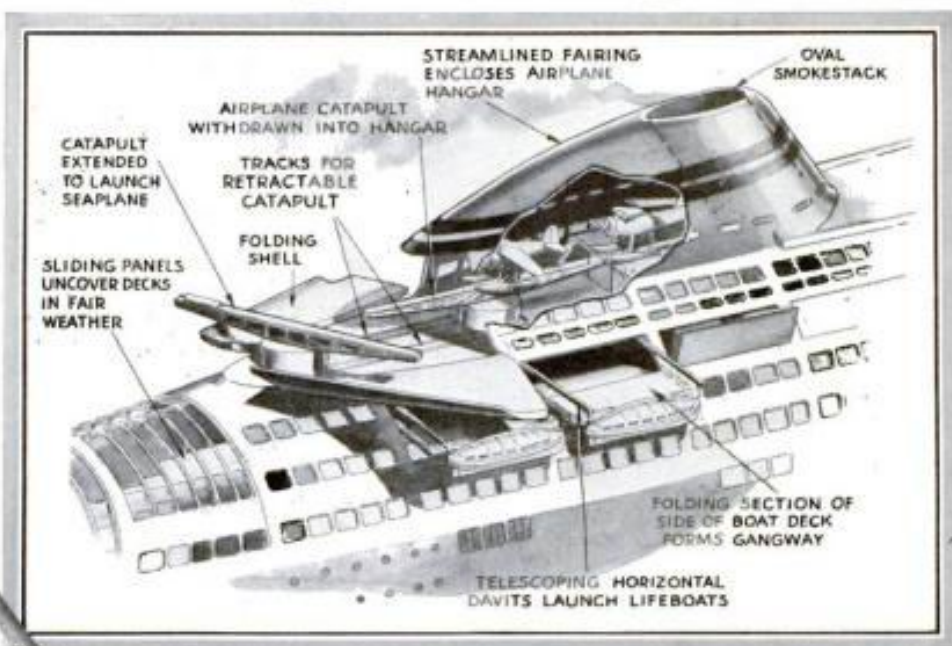
Cutaway view of Geddes' design for a streamlined ship, showing features of liner that will accommodate 2,000 first-class passengers

New Streamlining for Big Ships

*Radical Design
of Ocean Greyhounds
May Shorten Trip to
Europe by One Day*



FROM PHOTO BY MAURICE GOLDBERG



Above, some of the streamlined ship's mechanical details, including the airplane hangar, lifeboat-launching apparatus, and means provided to expose decks in fair weather. Left, view showing contour of the vessel

ARE liners of the sea destined to take on new forms in the race for speed? With streamlined trains and automobiles no longer a dream but a fact, as told in recent issues of *POPULAR SCIENCE MONTHLY*, designers are wondering where the new-born art of streamlining may work additional transformations. That streamlined ocean vessels will prove a logical development is the view of Norman Bel Geddes, noted industrial designer of New York, who since 1927 has been experimenting with ships, motor cars, factories, and railway coaches designed along advanced engineering lines.

Capable of being built and operated

successfully under conditions existing today, he maintains, is a 1,088-foot streamlined vessel that he has designed. Details of this striking craft, which he describes in his book, "Horizons," published by Little, Brown, and Company, give a fascinating picture of what sea travel of the future may be like.

Streamlined both in hull and superstructure, the passenger liner proposed by Geddes presents a striking contrast with present-day vessels. Every air pocket has been eliminated by inclosing the entire superstructure in a streamlined shell. Only the navigator's bridge protrudes, and this is shaped in the form of a monoplane wing so it offers a minimum of resistance to the air.

As a result of its smooth contour above the water line, and improved hull design

below water, its designer estimates that the ship's speed in normal weather should be at least twenty percent greater than that of conventional craft, or enough to clip a day from the transatlantic passage. In bad weather the advantage of the streamlined ship would be materially increased because it would not be adversely affected by strong head winds. Tests show the design would reduce wind resistance by about eighty percent.

Accommodations are provided on the liner, in Geddes' design, for 2,000 first-class passengers and for a crew of 900 men. Sliding panels of light alloy or glass in the streamlined skin provide for the comfort of the passengers in rain or shine. When the weather is fine, the moving panels are rolled back and the ship is more open than a liner of the present day. In stormy weather the panels are closed and the vessel is as impervious to the elements as a submarine. Thus, the fully streamlined form of the ship is preserved when most needed.

Smokestacks for the steam-turbine power plant of the streamlined craft are inclosed in fairing that makes them seem to dissolve into the superstructure.

POPULAR SCIENCE

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APRIL

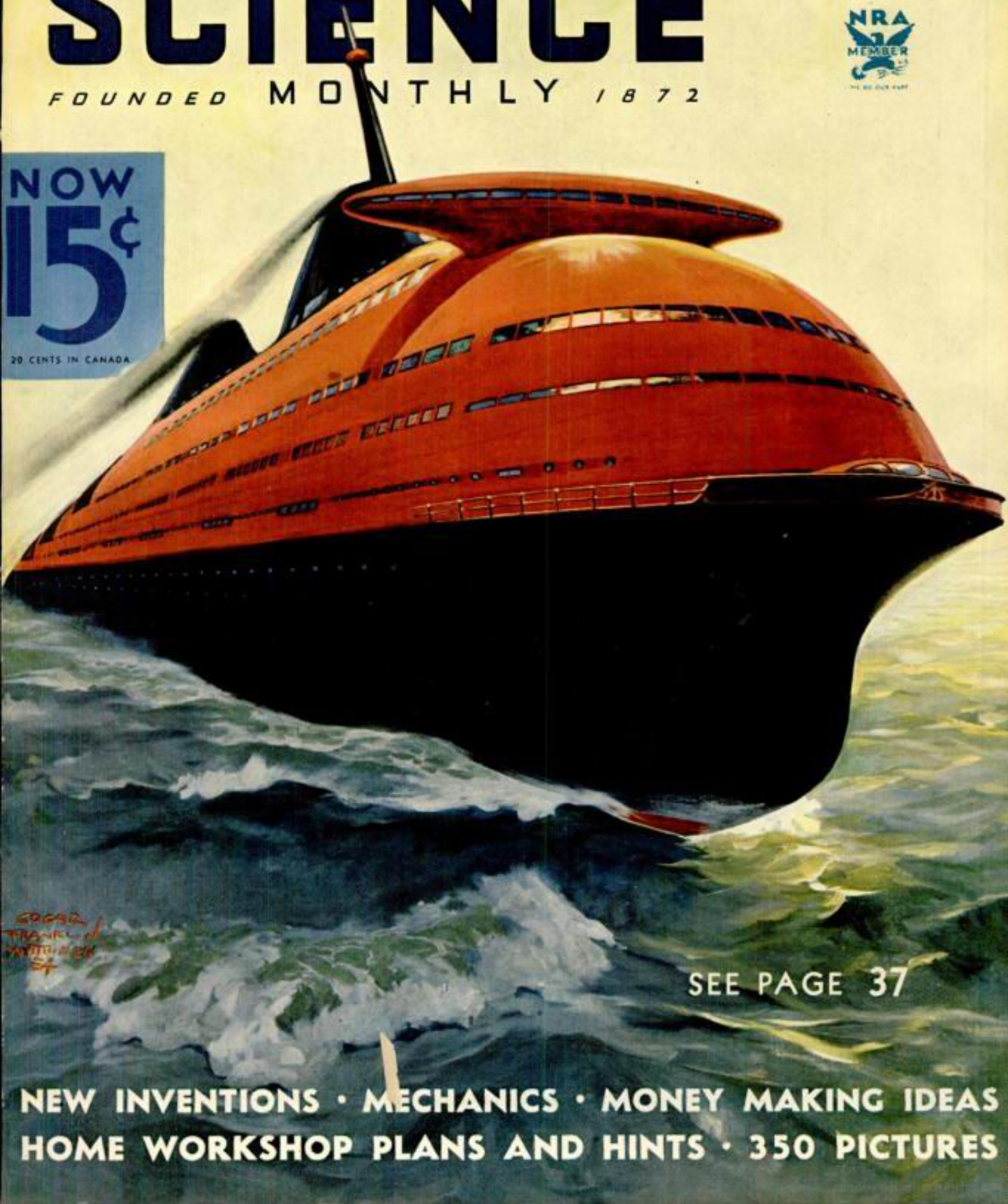
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SEE PAGE 37

NEW INVENTIONS • MECHANICS • MONEY MAKING IDEAS
HOME WORKSHOP PLANS AND HINTS • 350 PICTURES

Windmill Planes

OPEN NEW FIELD IN AVIATION

WHIRRING gyroplanes, and amazing wingless air machines that soar straight up, hover motionless, and even fly backward, may soon open a new chapter in the history of aviation. That is the prediction of 150 engineers and scientists, gathered a few weeks ago at Philadelphia, Pa., to discuss the remarkable recent advances of rotating-wing aircraft, and the problems that still confront their builders, in the first meeting of its kind ever held.

Proposed helicopter with gas-filled spiral wing. If engine fails, base containing motor and tanks is dropped



Nor was this mere prophecy. Spurred on by a \$2,000,000 grant from Congress for the study of all types of "whirligig" aircraft, for possible use by the Army, Navy, Coast Guard, Department of Agriculture, and a dozen Government bureaus, active production is soon to boom again.

The first machines to be developed in the big program will probably be gyroplanes, the fantastic "flying windmill" type of craft introduced in this country by the late Juan de la Cierva, in 1929. Holding forth a brilliant future, the autogiro and similar machines were beset with technical shortcomings that had to be solved before they could become a commercial success. After ten years of quiet



Autogiro in flight. It is a cross between helicopter and plane

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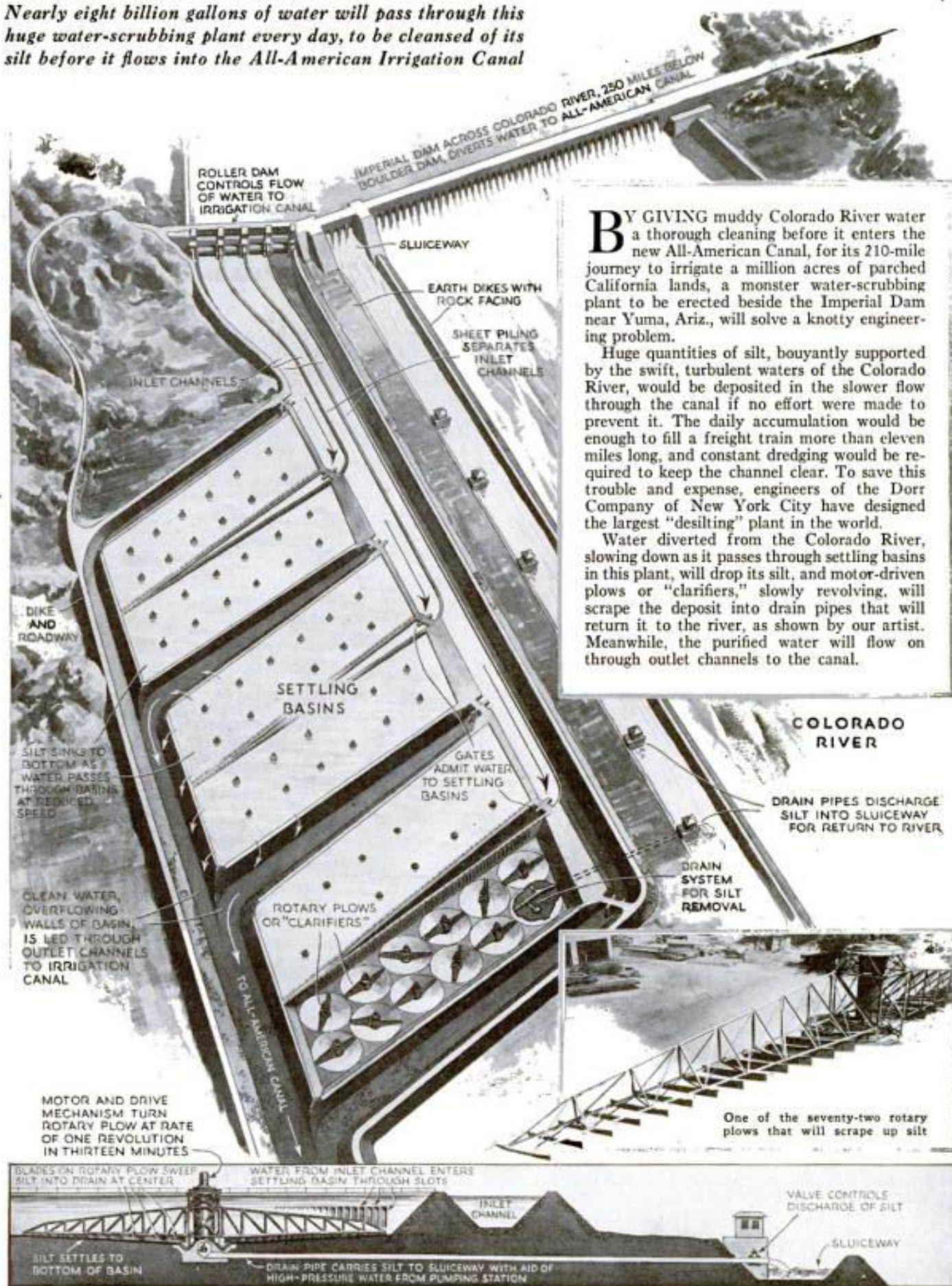
SEE
PAGE
124

INCORPORATING
Mechanics
AND HANDICRAFT

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FRANKLIN
MAGAZINE
CO.

Washing the Muddy Colorado River

Nearly eight billion gallons of water will pass through this huge water-scrubbing plant every day, to be cleansed of its silt before it flows into the All-American Irrigation Canal

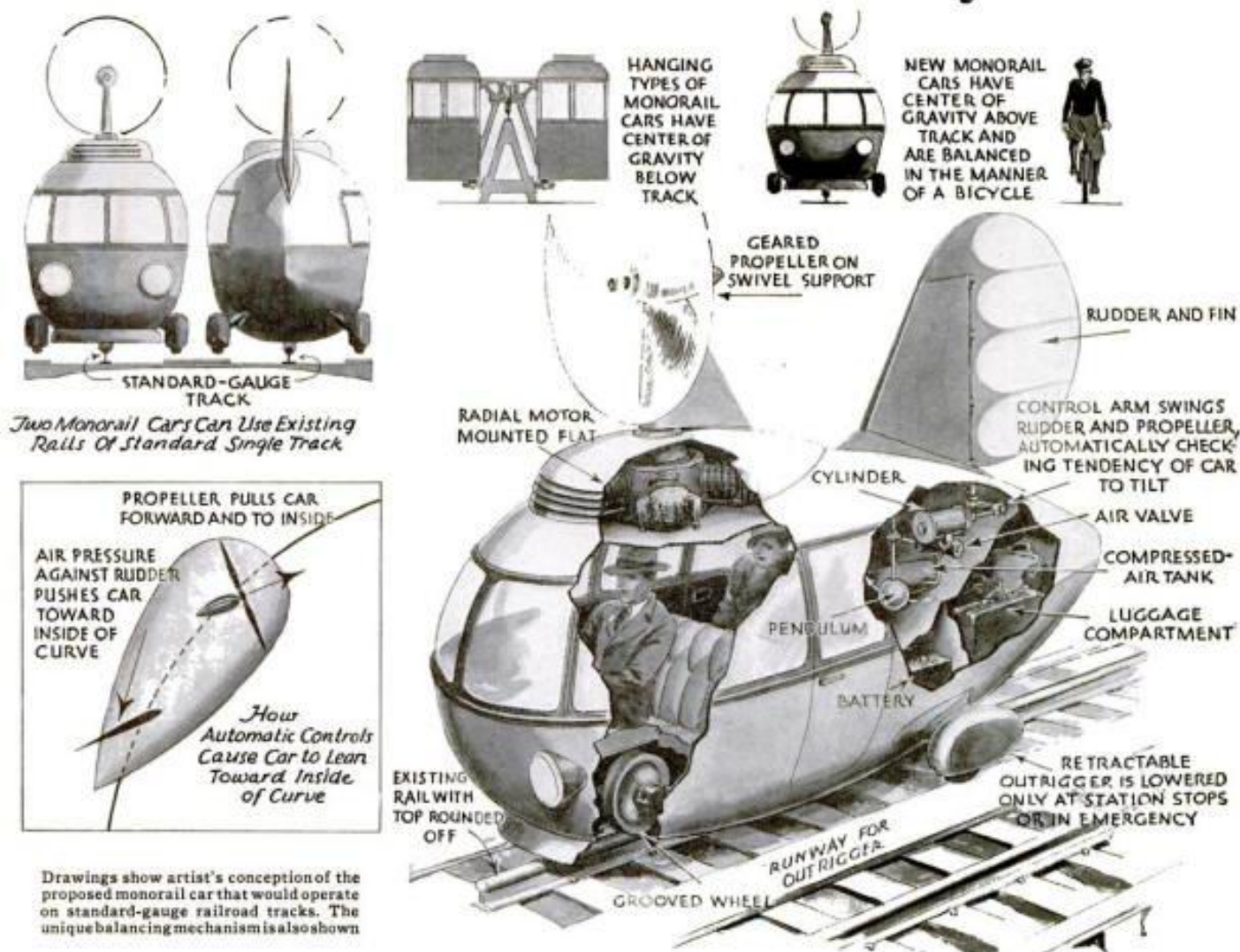


BY GIVING muddy Colorado River water a thorough cleaning before it enters the new All-American Canal, for its 210-mile journey to irrigate a million acres of parched California lands, a monster water-scrubbing plant to be erected beside the Imperial Dam near Yuma, Ariz., will solve a knotty engineering problem.

Huge quantities of silt, buoyantly supported by the swift, turbulent waters of the Colorado River, would be deposited in the slower flow through the canal if no effort were made to prevent it. The daily accumulation would be enough to fill a freight train more than eleven miles long, and constant dredging would be required to keep the channel clear. To save this trouble and expense, engineers of the Dorr Company of New York City have designed the largest "desilting" plant in the world.

Water diverted from the Colorado River, slowing down as it passes through settling basins in this plant, will drop its silt, and motor-driven plows or "clarifiers," slowly revolving, will scrape the deposit into drain pipes that will return it to the river, as shown by our artist. Meanwhile, the purified water will flow on through outlet channels to the canal.

Monorail Car Rides Ordinary Tracks



Drawings show artist's conception of the proposed monorail car that would operate on standard-gauge railroad tracks. The unique balancing mechanism is also shown.

MONORAIL cars capable of using the rails of existing transportation lines are proposed by a Cleveland Heights, Ohio, inventor. Thus he would obviate the expensive new construction called for in many monorail projects, and would provide a self-propelled vehicle that could be used by railroads either to replace or to supplement regular trains.

Since the new car is designed to ride wholly above the supporting rail, some means is required to prevent it from toppling. The ingenious mechanism worked

out by the inventor operates on the principle that a bicycle rider uses to remain upright. The air propeller that pulls the car is so mounted that it may be turned toward either side to counteract any tendency of the car to tilt, much as a man on a bicycle leans toward the inside of the curve in making a turn. An additional means of balancing is provided by an air rudder at the rear of the car. The two balancing devices are interconnected and operated automatically by a compressed-air mechanism, in response to the action

of a sensitive pendulum that detects any deviation from an upright position. When the car stops at a station, outriggers on each side may be lowered to support the car on auxiliary wheels.

Even more similar in operation to a bicycle is a simpler form of the monorail car designed by the inventor for light traffic. Here the automatic balancing control is dispensed with and the driver balances the car with a hand lever resembling bicycle handlebars. In the smaller forms, either propeller or rudder may be omitted.

BOLT DRIVEN INTO STONE LIKE A NAIL

AN EXPANSION bolt just placed on the market can be driven like a nail into brick, stone or concrete. Made of spring steel, the bolt is slit for about half its length and the two sides forced apart to form a bulge. The end of the bolt is inserted in a hole drilled in the stone or concrete, and driven into place with a hammer. The bulging sides exert a tremendous outward pressure, holding the bolt firmly in place. It is made with several types of head.



TELESCOPE CAMERA MAKES LONG SHOTS

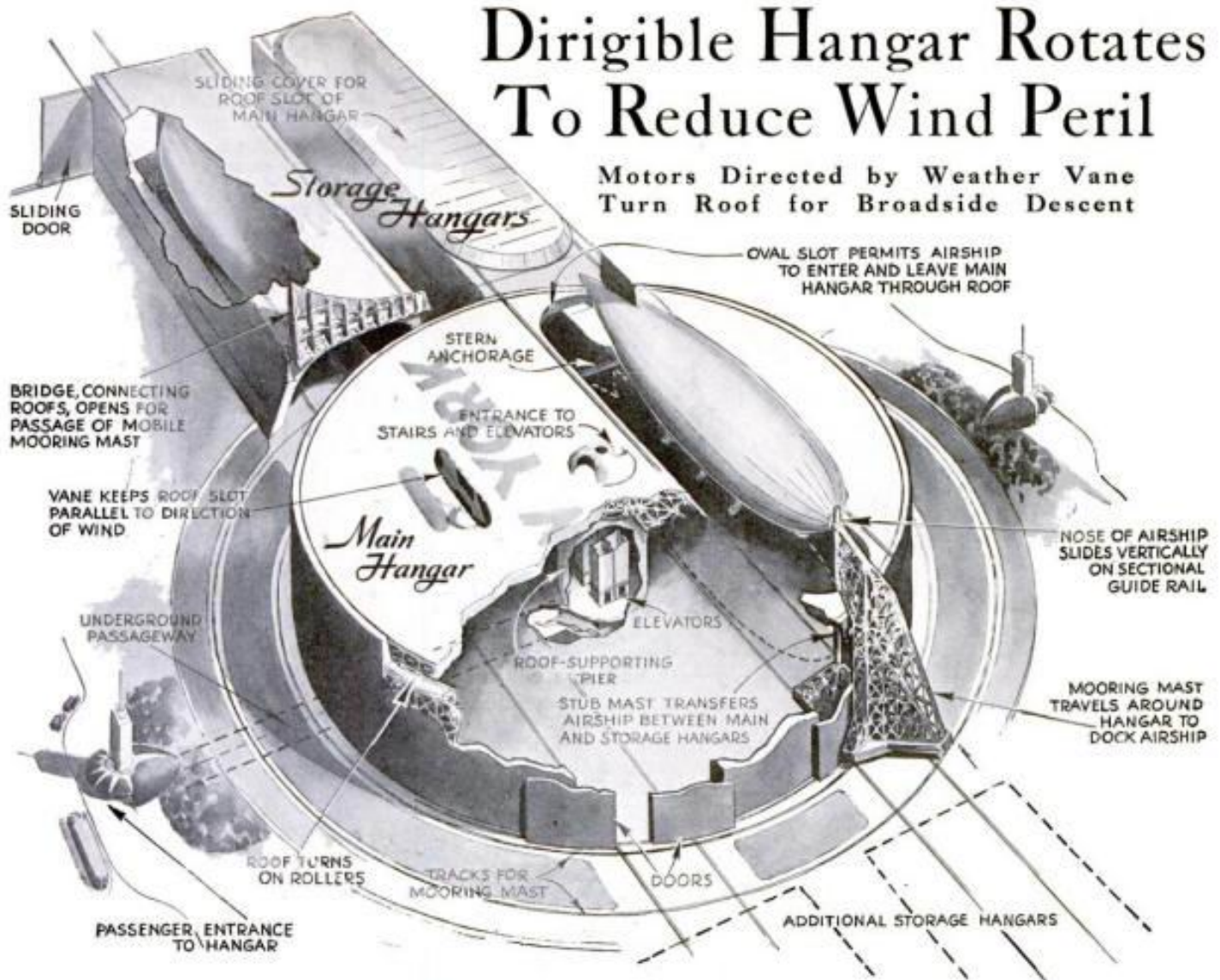
To get close-up pictures of mountain scenery from distant points of vantage, a photographer has constructed a camera resembling a telescope. Sliding cylindrical sections give it enough extension to accommodate a lens of four-foot focal length, which makes a remote peak seem only a few steps away. To hold the instrument steady in the wind, its owner has supplemented its standard tripod with a two-legged brace attached to the rear of the platform.



Long-range camera mounted on its novel wind-resisting base

Dirigible Hangar Rotates To Reduce Wind Peril

Motors Directed by Weather Vane
Turn Roof for Broadside Descent



A NEW way of docking dirigibles, proposed by a New York inventor, would avoid exposing them to the peril of a sudden sideward gust of wind while being walked in or out of a hangar door. A "hatbox hangar," permits the craft to be lowered or raised broadside through an oval aperture in the hangar roof. This slot is automatically kept

aligned with the direction of the wind by electric motors, operated by a wind vane, which rotate the entire hangar roof on rollers. An incoming airship is taken in tow by a mobile mooring mast and brought into position for passengers to use the roof as a landing platform. The ship is then maneuvered over the entrance slot, where it is made fast to guide rails and lowered

into the hangar. Elevators convey passengers between the roof and the ground level, where an underground passage offers access to the exterior. Additional equipment of the "hatbox hangar" may include power cars or "electric mules" to aid in handling the mooring lines, and mobile stub masts for moving airships about within the hangar.

CYCLE RIDES SNOWDRIFTS



Snow cycle in use, showing how skis at side keep the novel machine in balance

FOR TRAVELING at high speed across snow-covered country, an inventor of Munich, Germany, has introduced a motor cycle with an endless tread. A flexible belt, passing around front and rear wheels and supported midway by auxiliary rollers, propels the machine and keeps it from sinking into drifts. Seated astride this odd vehicle, the rider balances himself by means of skis. A fast ride over hard-packed accumulations of snow offers exhilarating sport.



DESK TOOL SEALS MAIL IN TWO RAPID MOTIONS

WITH THE aid of a handy new desk accessory, envelopes are quickly and neatly sealed. When the appliance is drawn along the flap of the envelope as shown in the photo, water from a felt pad moistens the gum. The sealer is then passed over the flap again, this time on the outside, closing the envelope.

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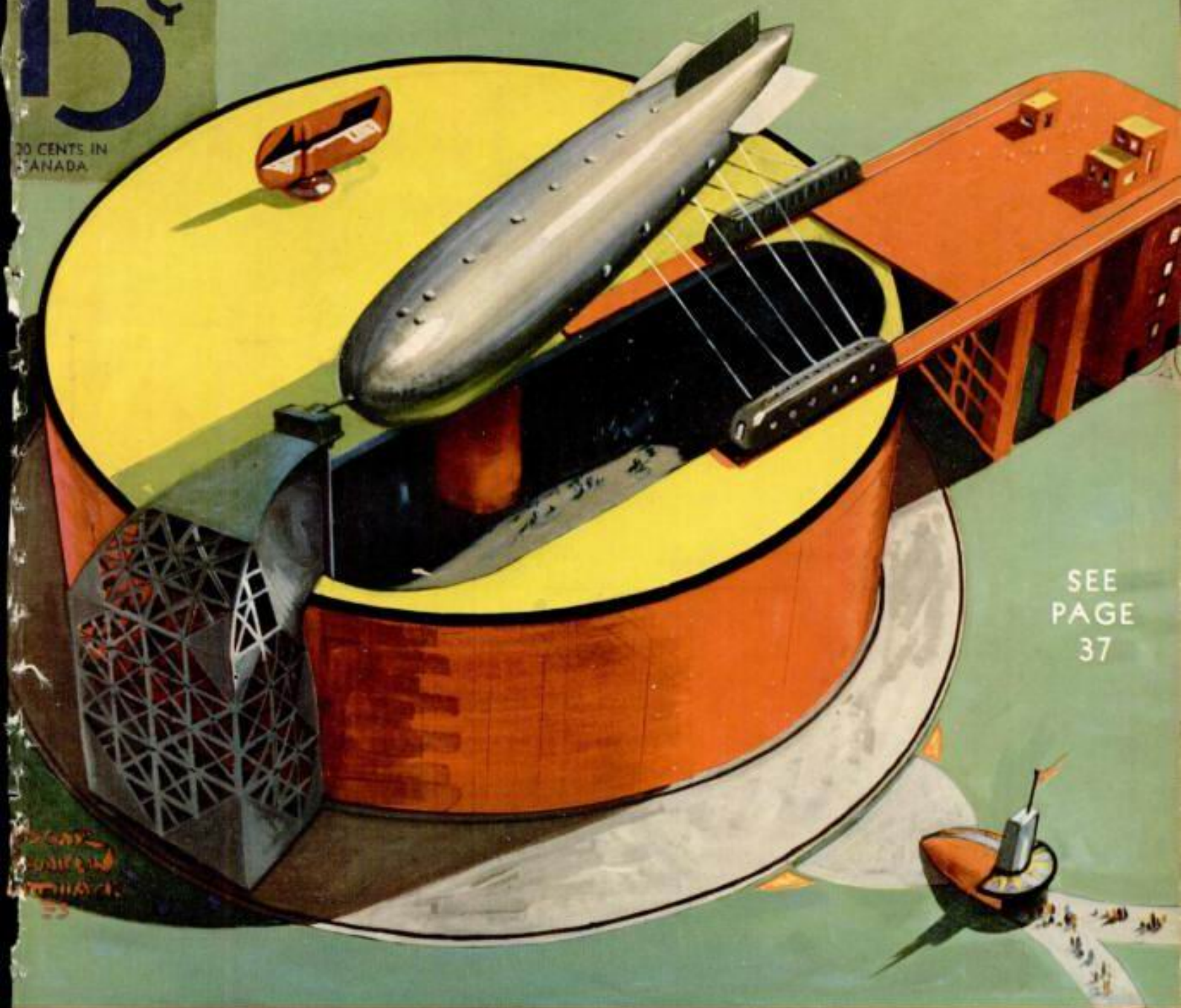
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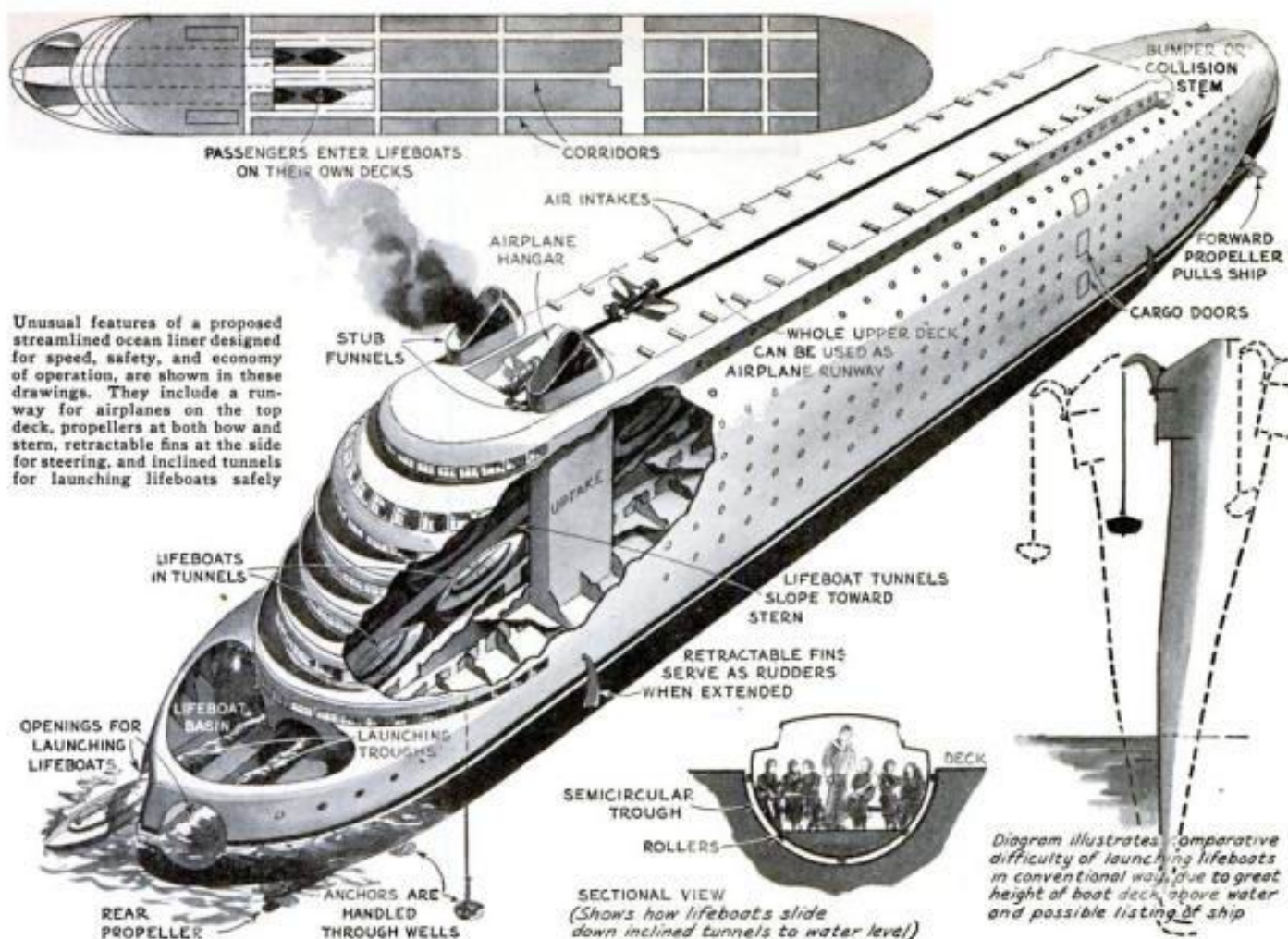
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37

NEW INVENTIONS • MECHANICS • MONEY MAKING IDEAS
HOME WORKSHOP PLANS AND HINTS • 350 PICTURES



Unusual features of a proposed streamlined ocean liner designed for speed, safety, and economy of operation, are shown in these drawings. They include a runway for airplanes on the top deck, propellers at both bow and stern, retractable fins at the side for steering, and inclined tunnels for launching lifeboats safely

Diagram illustrates comparative difficulty of launching lifeboats in conventional way, due to great height of boat deck above water and possible listing of ship

Safety Liner Has Lifeboat Chutes

SLIDING lifeboats smoothly into the water at sea level, instead of dangling them precariously from davits high above the waves, is the means proposed by a New York inventor for carrying passengers and crew to safety in case of accident at sea. The novel scheme for launching boats is a part of a design that he has evolved for a new type of ocean liner combining speed, safety, and economy of operation. Inclined

tunnels within the after end of the vessel serve as launching ways for large, motor-driven lifeboats, which slide on rollers into a basin open to the sea and emerge through openings in the stern. Since the boats take to the sea on an even keel, there is no danger of capsizing, and they may be launched without difficulty even when the vessel is listing at an angle that would make it impossible to lower half the

lifeboats of a conventional liner. Other striking features of the proposed design include a streamlined superstructure, a top deck that serves as an airplane runway, and the use of propellers at both bow and stern, together with finlike rudders along the sides, to distribute strains evenly along the hull instead of concentrating them at the stern, as in the case of ships of conventional design.



PLUNGER CHARGES NEW HIGH-POWER AIR PISTOL

SUITABLE for target shooting and hunting small game, an air pistol of new design discharges its projectiles with such force and velocity as to give high accuracy of fire. Either lead pellets of .177 caliber or darts are used as ammunition. To charge the gun with compressed air, a plunger just below the rifled barrel is drawn out and forced back several times, as shown above, operating an air pump. The air charge thus stored is released by pulling the trigger.

WHITE ROBES CAMOUFLAGE SOLDIERS

GARBED in flowing robes and hoods of white, artillerymen of a Polish mountain battery presented a striking appearance as they maneuvered their guns into position, during recent military maneuvers among the snow-covered Carpathian peaks. The odd costumes served the purpose of camouflage, rendering the soldiers virtually invisible against the background of snow when viewed from the air. Squares of white cloth rigged on poles above the guns concealed them. The picture shows five white-clad men and a field gun.



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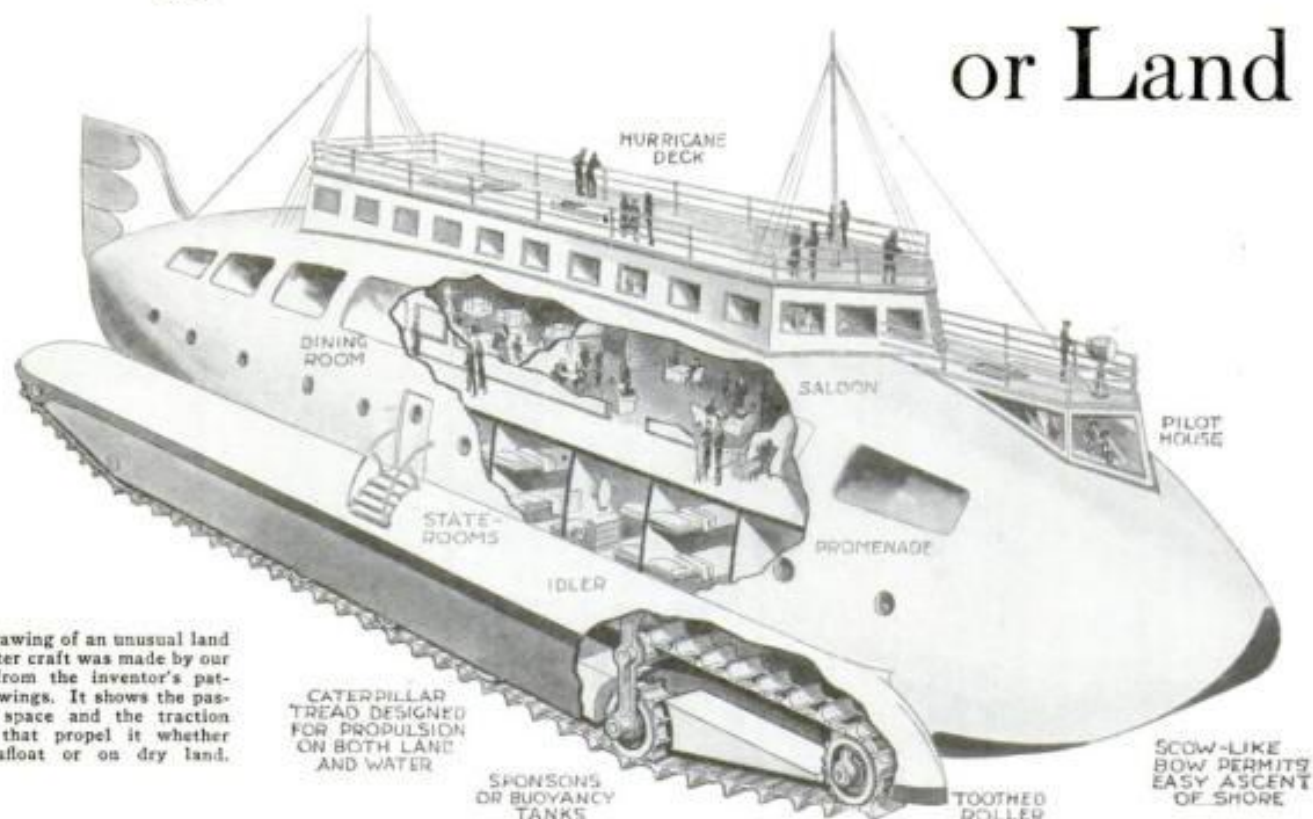
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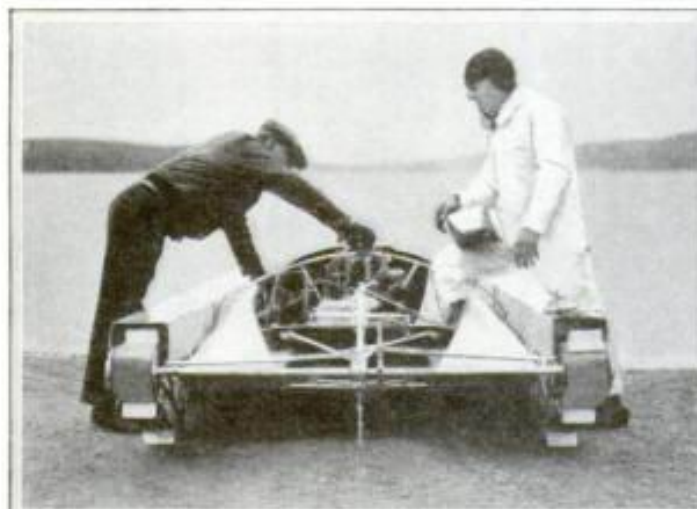
See Page 35

**NEW INVENTIONS • MECHANICS •
HOME WORKSHOP PLANS AND HINTS
MONEY MAKING IDEAS • 350 PICTURES**

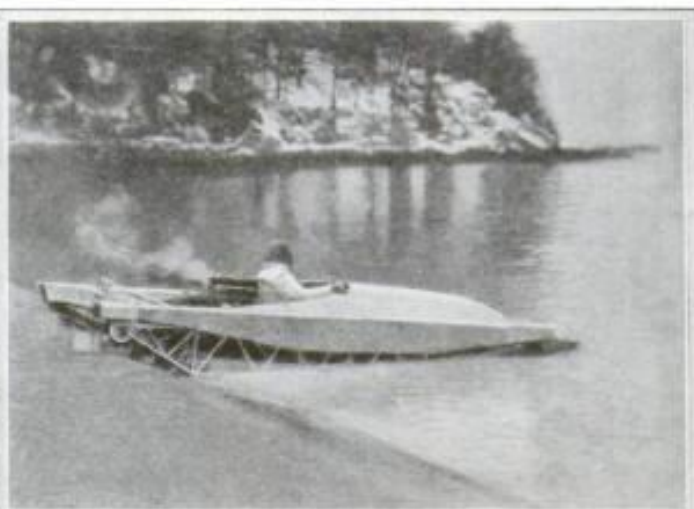
Strange Craft at Home on Water or Land



This drawing of an unusual land and water craft was made by our artist from the inventor's patent drawings. It shows the passenger space and the traction drives that propel it whether it is afloat or on dry land.



Peter Prell, right, inventor of water-land boat, gets ready to run it into the river.



Like some big turtle, the craft crawls into the water.

AN ODD craft recently swept along the Hudson River near Fort Lee, N. J., and then climbed up the bank and raced with a crunching noise along the shore. It was the invention of Peter Prell, of Union City, N. J., who built it to demonstrate his ideas of a boat that can travel either on water or land.

Small paddles on endless belts, running from bow to stern at each side of the boat, propel the odd amphibian in the



On each side the long line of shallow paddles send the water flying as Prell's remarkable craft proves its ability to travel at a fast clip during a serious water test.

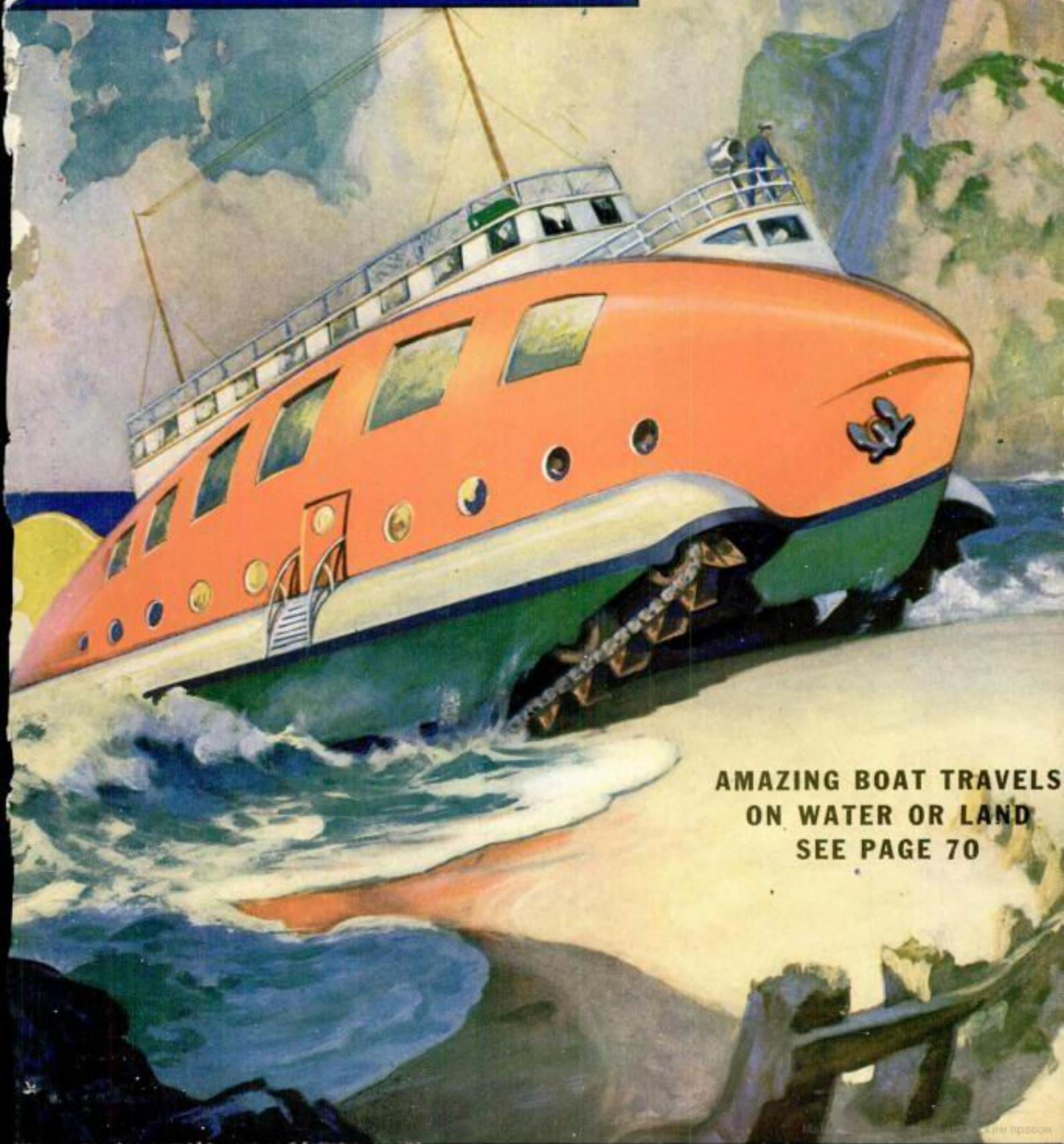
water, and serve as tractor lugs to enable it to crawl over land. Prell has designed and applied for patents on a larger craft, built on the same principle and powered by Diesel-electric machinery. Such vehicles, he declares, might carry a hundred passengers. They would be particularly well adapted for river navigation, and on a winding river could save time by crawling across the spits of land that form the bends.

POPULAR SCIENCE

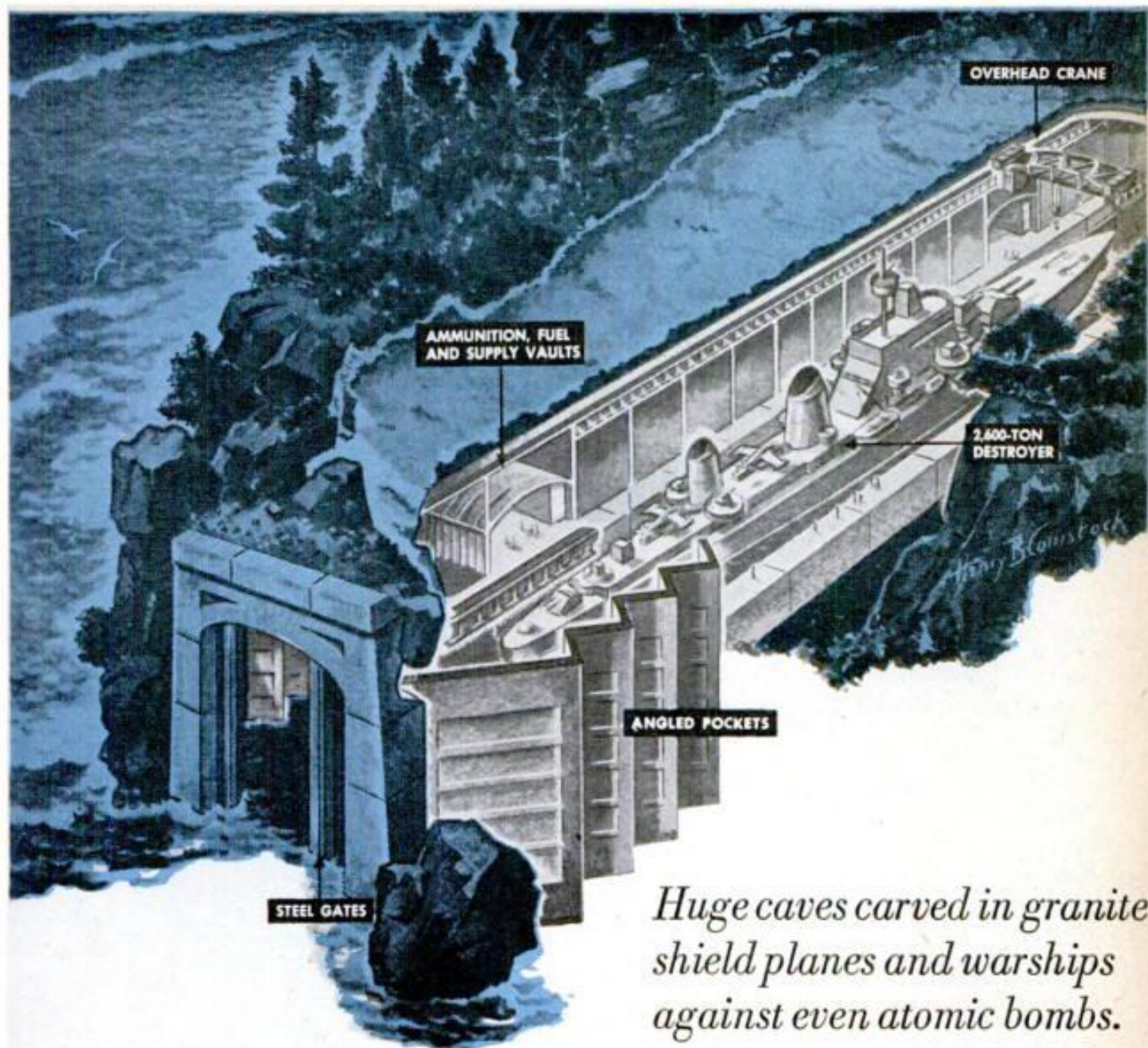
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AMAZING BOAT TRAVELS
ON WATER OR LAND
SEE PAGE 70



Huge caves carved in granite shield planes and warships against even atomic bombs.

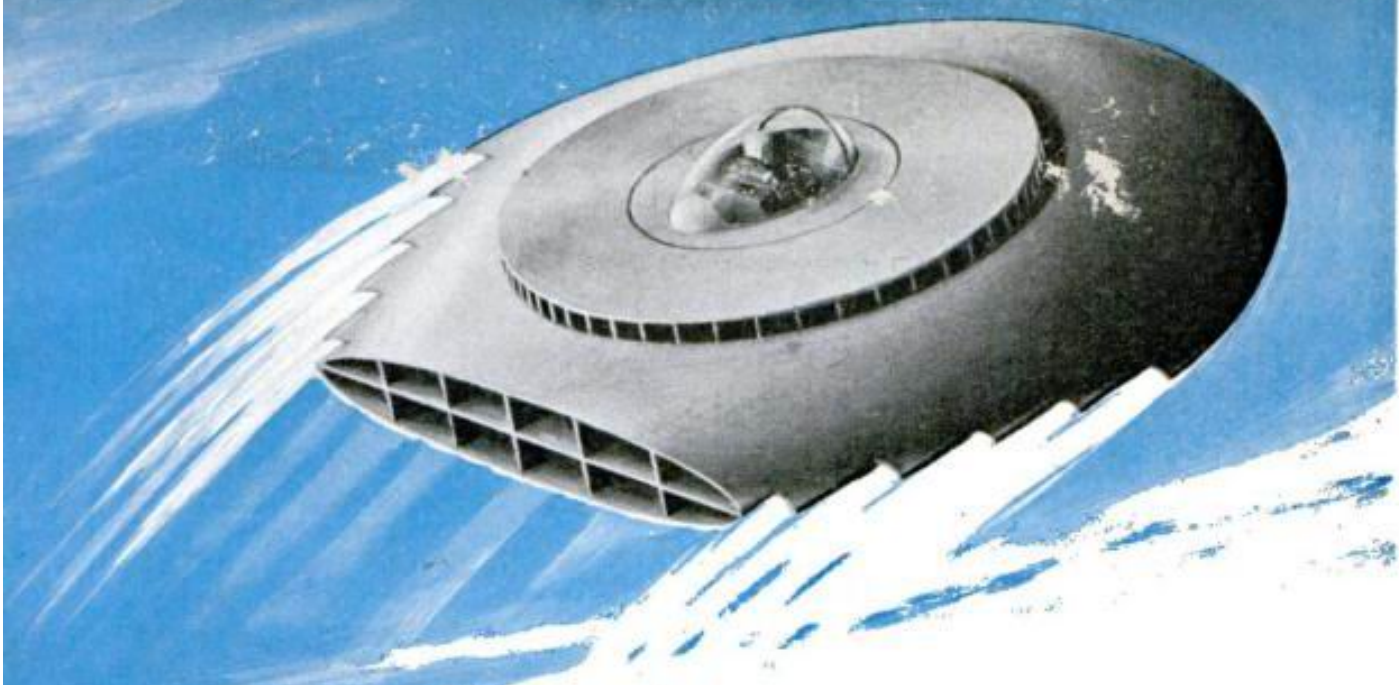
Swedes Hide Punch Under Mountains

HER blue and gold ensign fluttering, the big destroyer heads straight for shore. Ahead looms a rocky cliff where one of the hundreds of islands that fringe the Swedish coast drops into the sea. But suddenly a huge hidden door swings open.

In a moment the ship has vanished into the mountainside. The gates swing shut. The sea is empty.

This disappearing act is Sweden's answer to a grim bit of military geography. From the nearest Russian island to Stockholm is just 145 miles as a bomber flies. The Swedes are determined never to have a Pearl Harbor.

Inside the mountain, the destroyer berths in a tunnel 96 feet high and 57 feet wide, blasted out of solid granite. The entrance is protected by heavy gates;

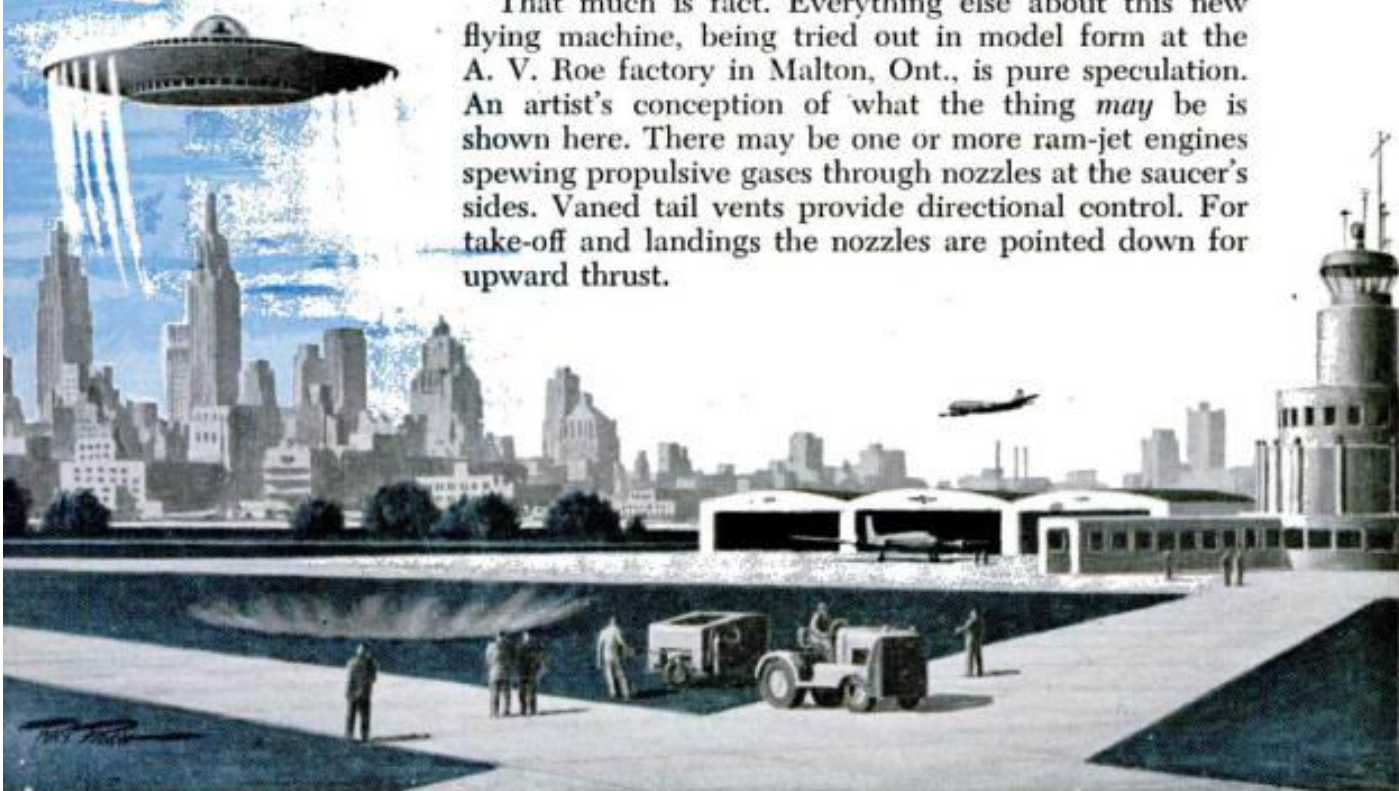


Real Flying Saucer Designed for 1,500 M. P. H.

A FLYING saucer—the real McCoy this time—is being tested in Canada.

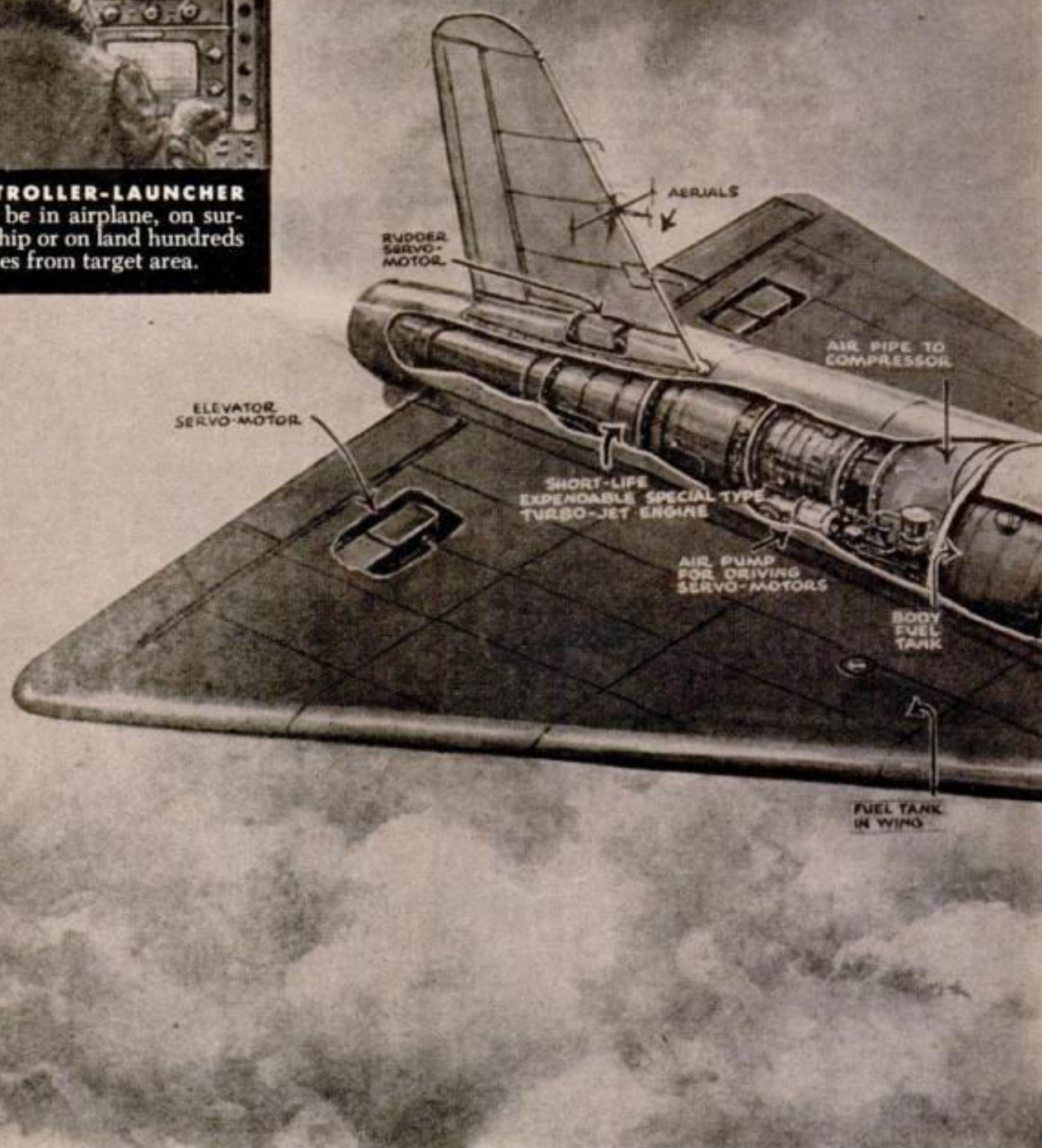
It is designed to carry a pilot—not an organism from outer space, but a genuine human being. The people in charge of the project figure that it will go 1,500 miles an hour. It will take off straight up and land straight down. The power plant is revolutionary. The pilot sits in a little island in the center of the saucer with the engine around him.

That much is fact. Everything else about this new flying machine, being tried out in model form at the A. V. Roe factory in Malton, Ont., is pure speculation. An artist's conception of what the thing *may* be is shown here. There may be one or more ram-jet engines spewing propulsive gases through nozzles at the saucer's sides. Vaned tail vents provide directional control. For take-off and landings the nozzles are pointed down for upward thrust.





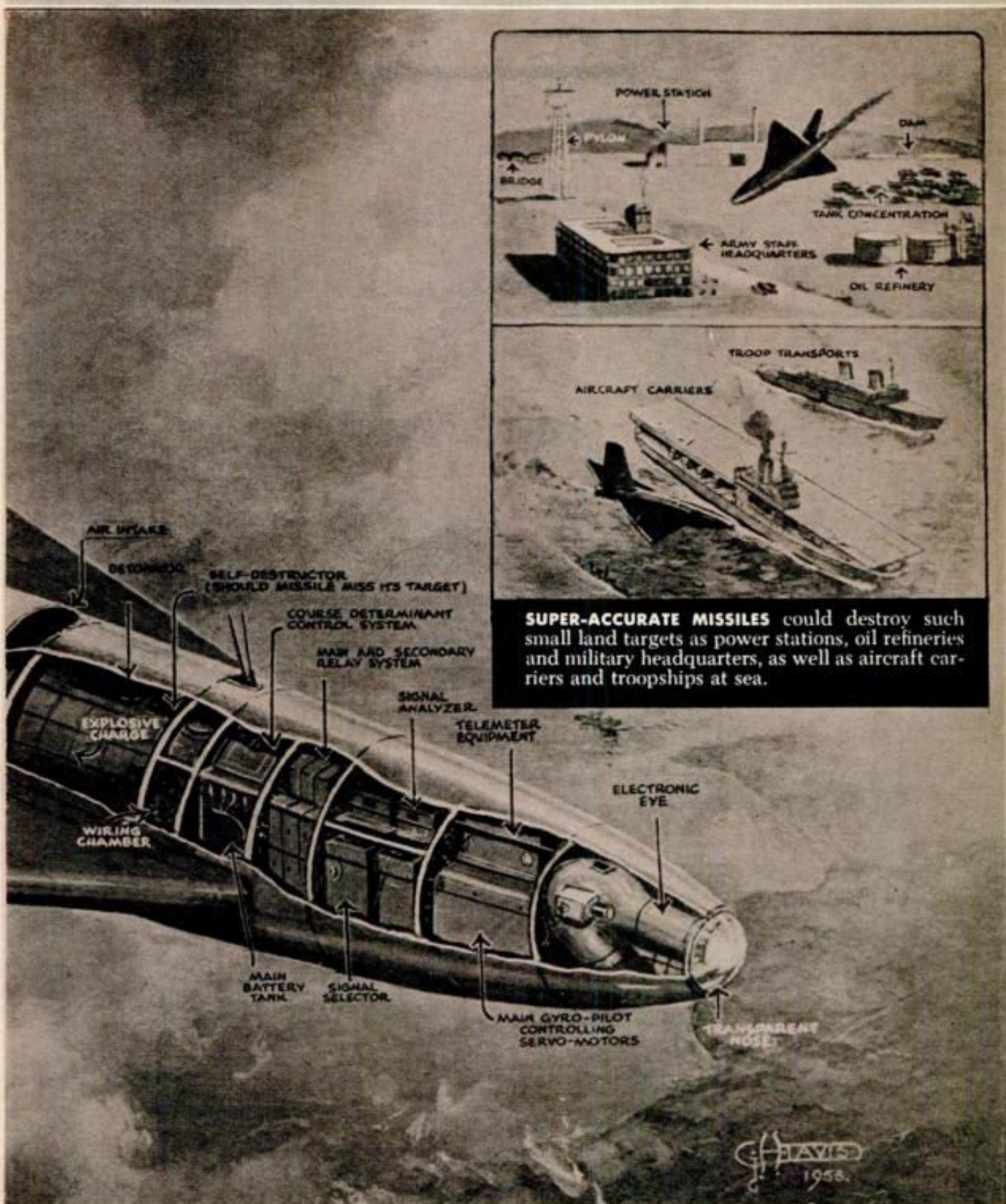
CONTROLLER-LAUNCHER
could be in airplane, on sur-
face ship or on land hundreds
of miles from target area.



Seeing-Eye Jet Proposed as Robot Raider

LONG-RANGE missiles that can "see" and home on their targets are being designed by the British. The illustration above, from the *Illustrated London News*, is a conception by the artist G. H. Davis of how one of the weapons might look.

The nose is a radome that transmits



SUPER-ACCURATE MISSILES could destroy such small land targets as power stations, oil refineries and military headquarters, as well as aircraft carriers and troopships at sea.

what it "sees" to equipment that digests it and puts the missile on course. The only human hand involved in its flight is that of the controller who launches it. He can be hundreds of miles from the target.

The delta-wing missile pictured would

be propelled by an expendable jet engine—the same kind powering fighters and bombers. Its speed would be considerably short of 1,000 m.p.h.—far less than that of rocket-powered missiles. In case it got off course, it would be equipped to destroy itself in the air. **END**



The File Clerk Gets a Lift

THIS file clerk does all her work sitting down. A hydraulic lift raises desk, chair and clerk as high as five feet alongside the circular file. The unit also rolls forward or backward. The Wassel Organization, Inc., Westport, Conn., makes it.



Power Stick Fells Trees

A ONE-CYLINDER engine drives a 12-inch chain saw to cut down trees up to five inches in diameter. An interchangeable cutting head converts the tool to a power scythe for mowing weeds. Hoffco, Inc., Richmond, Ind., is the maker.

How You'll Fly in 1975

WHEN you buy a flight ticket in 1975, you will step aboard a transport with a long, slim fuselage and wings so far back that they look almost like extra-large tail surfaces. And you will fly almost as fast as sound.

Military aircraft, too, will change drastically. Interceptors and bombers—those flown by human pilots—will streak to their targets at velocities much faster than sound. And even these swift jets will give way to rocket-powered missiles that can hit an enemy on the other side of the seas.

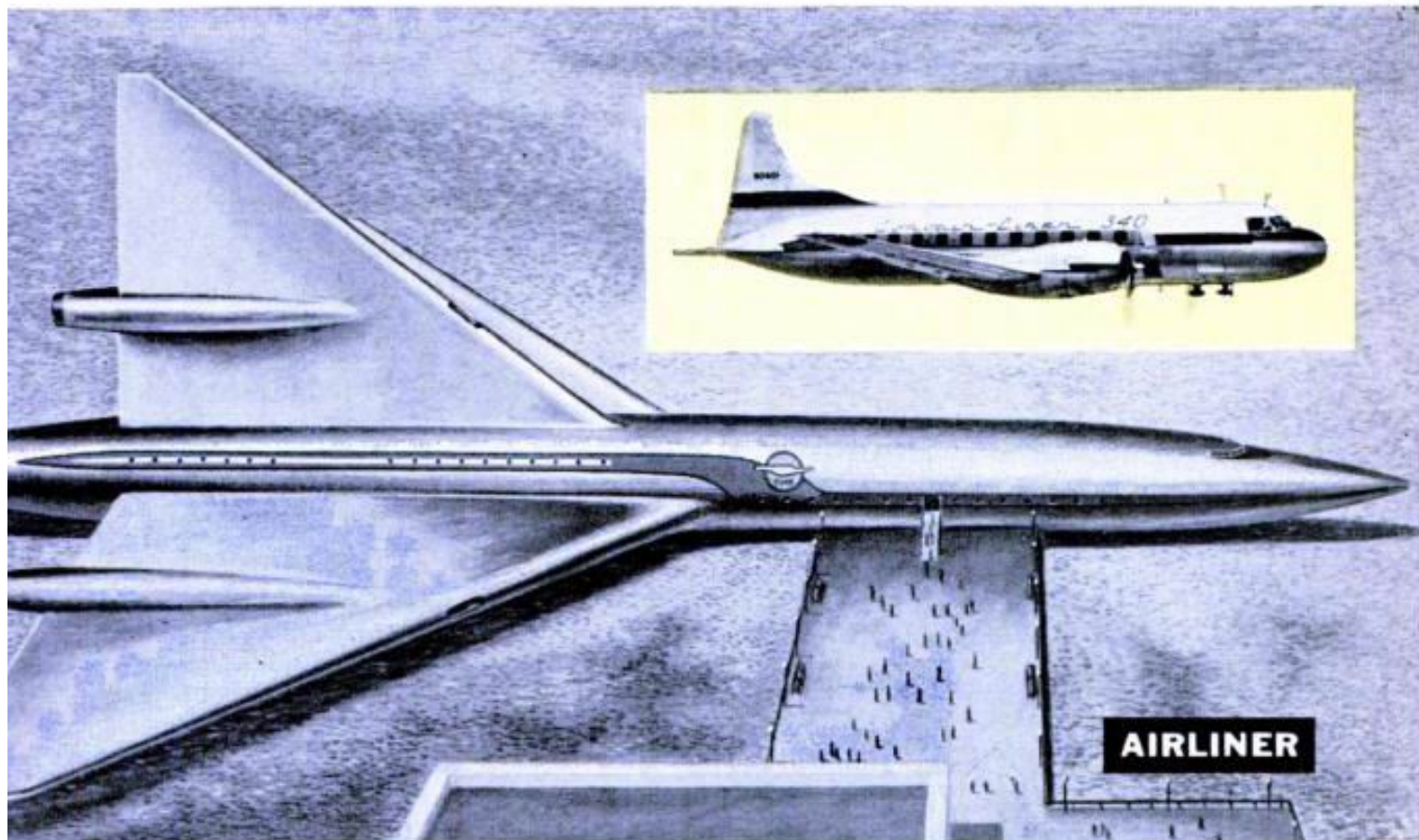
What you see on these pages are dramatizations of the shapes to come—dreamed up by Consolidated Vultee experts. But engineers generally wrap their dreams around a hard core of fact. Ten years ago, supersonic speed, now commonplace, was only a gleam in an optimistic engineer's eye.



FIRST DELTA-WING PLANE ever flown, the XF-92A, above, was forerunner of the F-102 interceptor. It appears cumbersome compared with shapes to come.



TODAY'S INTERCONTINENTAL BOMBER can fly halfway around the world. Power from jets helps piston engines for short bursts of speed. It will top 435 miles per hour.



GIANT DELTA-WING SEAPLANE, shaped like a toy dart, is the dream design that Consolidated Vultee engineers expect will supplant present Convair 340 for passenger service. The

transport of the future would have a jet engine in vertical stabilizer as well as in each of the sharply swept wings, but is planned for near-sonic, not supersonic, speeds.



FIGHTER

FUTURE INTERCEPTOR, flying from land or water, will reach very high speeds. Rake ahead splits air in supersonic flight. External gingerbread has disappeared.

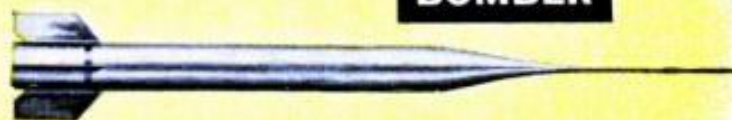


INTERCEPTOR MISSILE with large control fins would permit faster maneuvering to hit incoming bomber. Ground-fired, it could fly at speed of several thousand miles an hour.



BOMBER

ALL TOMORROW'S MANNED BOMBERS may be propelled by jets alone. Unlike the B-36 at left, some may be able to take off and sit down on land or water.



GUIDED MISSILE able to cross an ocean may replace bomber aircraft. Wings may disappear completely and fins operated by electronic brain guide missile to target.



Newest wing is the
crescent shape of
the British Handley-
Page Victor.

Who Is Building the Best Bomber?

Long-range jet bombers of today are no better than their wings.

By D. M. Desoutter, *Assistant Editor of the British magazine Aeronautics.*

AIRPLANE designers of Britain and the United States are engaged in a contest of wits. On its outcome may depend the defense of the West. The question: What's the best shape for the wings of a long-range jet bomber?

The striking differences among their

latest answers were underscored when the wraps of secrecy were partly removed recently from the newest British bomber—the crescent-wing Handley-Page Victor (PSM, March '53, p. 170). The sketches at the top of these pages show how radically the design of the new Victor



Delta wing of the British Avro Vulcan makes plane look like a triangle.

Sharp sweep back identifies the thin-winged U. S. Boeing B-52 Stratofortress.

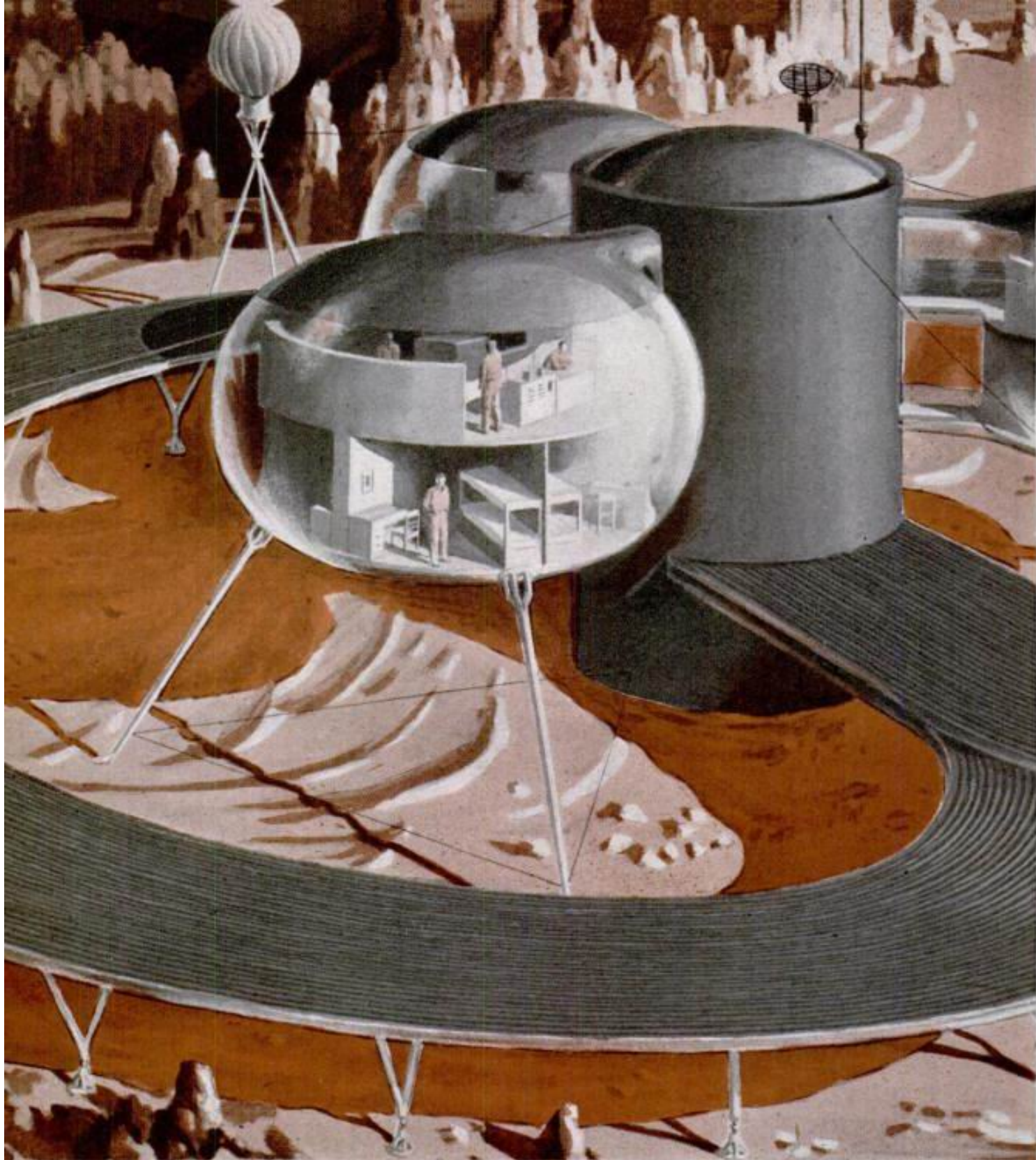
But designers disagree as to what shape of wing is the best.

departs from that of the British delta-wing Avro Vulcan and how little both of these planes resemble in external appearance the thin, swept-back wing of the American Boeing B-52 Stratofortress.

Yet all three were designed to do the same job: to fly great distances at altitudes around 50,000 feet and at speeds very close to the speed of sound. These

bombers are built to fly at a speed just below that of sound for a very practical reason: To force an enemy to take on the thunderclap hazard of crossing and recrossing the sonic barrier every time he tries to intercept them.

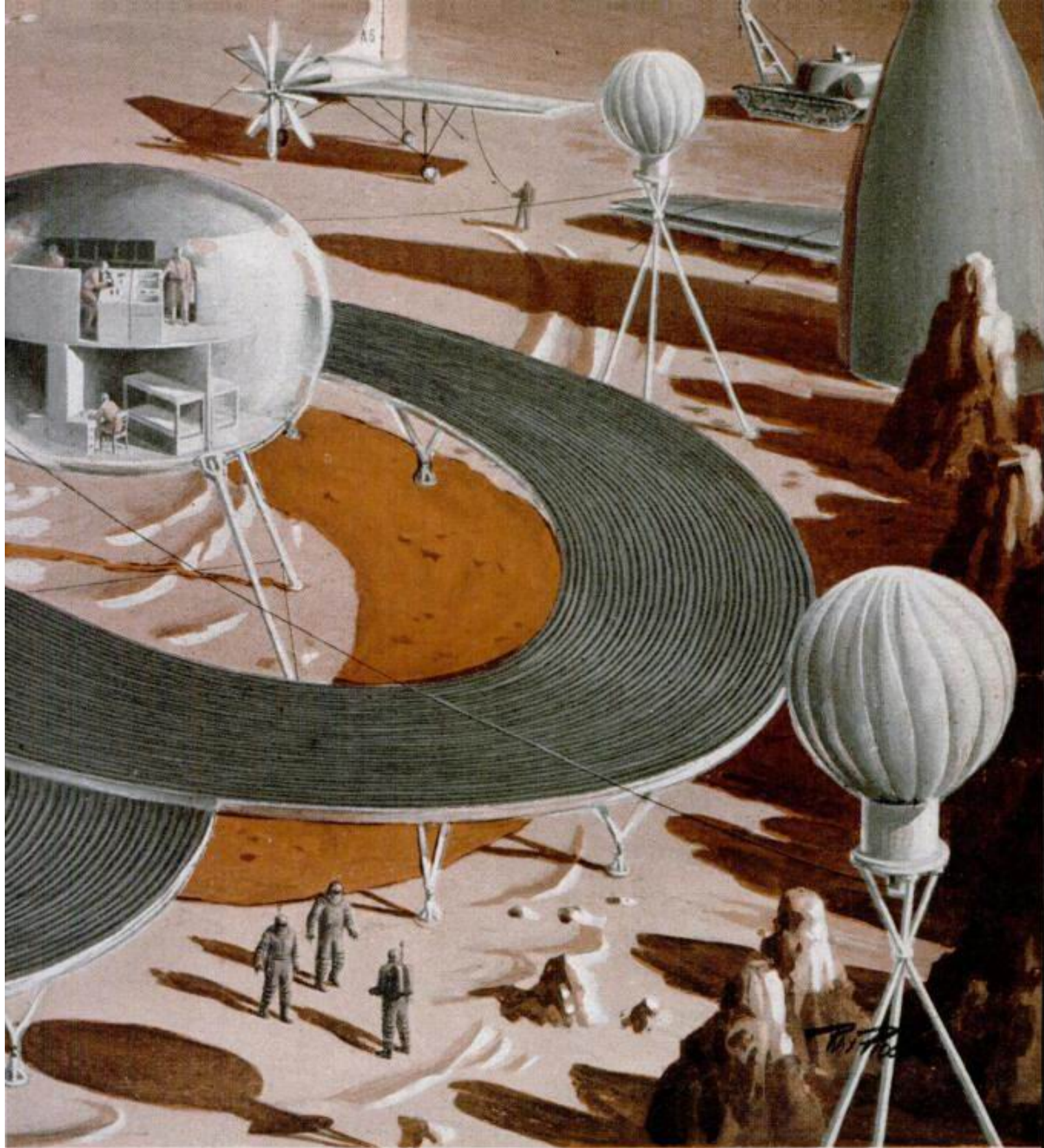
All the designers thus were faced by the same problem—to plan a plane that would fly just below the sonic barrier



Proposed Mars base looks like this. The heart-shaped ring captures solar heat to warm living

How We'll Live on Mars

A bold scientific report describes an amazing scheme that would let a party of 33 set up housekeeping on our neighbor planet.



quarters for 33 men in spheres and cylinder. Plane and tractor will run in oxygenless air.

By Alden P. Armagnac

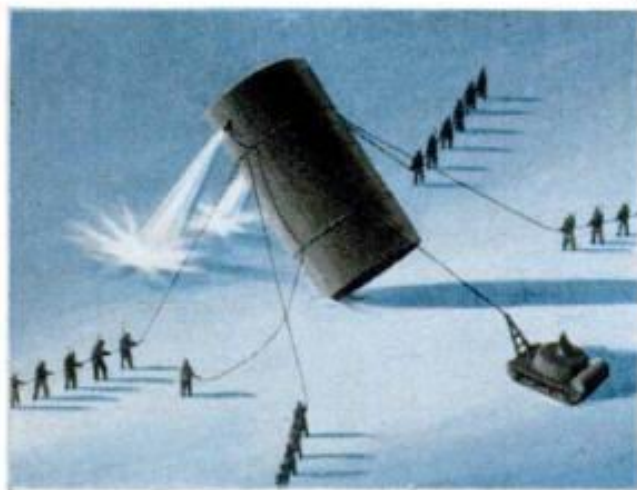
WHEN the first expedition from Earth sets foot upon the planet Mars, 33 courageous men will make up the landing party.

From a winged rocket ship that has swooped to a horizontal landing on

wheeled gear, they will emerge wearing pressurized suits and oxygen helmets.

As they step to the dusty red ground, one of their number beyond doubt will plant a flag to mark the history-making achievement. But there will be scant time for ceremony.

For the landing party's first and press-



AS FIRST STEP IN SETTING UP BASE, landing party's rocket ship is stripped of nose and wings, and jato units are attached at end of remaining aluminum-clad cylinder. Steadied by lines, it is up-ended to form hub of base.



SOLAR HEATER, plastic envelope containing six-inch air ducts, is first of extensions to emerge from hub. As compressed air inflates loose folds, it forms a ring 16 feet wide and nearly 150 feet in over-all diameter.



PLASTIC SHELLS forming living and working spaces now emerge from other ports of cylinder. Expanded, they form three flattened spheres, each about 32 feet wide and 20 feet high, containing an artificial atmosphere.

ing task will be to erect living quarters that will house the 33 and enable them to survive a 430-day stay in Mars' rarefied and oxygenless atmosphere before returning to Earth.

Seen from a distance, the weird structure forming their completed base will look like a number of eggs propped up and balanced on toothpicks. Because it must be engineered especially to suit the novel conditions on Mars, and to be transported there in a rocket ship, it will resemble nothing ever seen here on Earth.

Master's Thesis Studies Problem

So unusual and challenging are the problems of designing a Martian base that a special study of them has just been made. The result, a 79-page thesis entitled "A Prototype Technical Research Center for Extraterrestrial Exploration," has been submitted by Alfred William Moffett in partial fulfillment of the requirements for the degree of master of architecture at Massachusetts Institute of Technology.

In preparing it he has had the interested assistance of a panel of experts including leading MIT and government scientists. For authentic information on even the most minor points, he has pored through scores of technical treatises and scientific reports. Thus he arrives at the documented and authoritative conception summarized on these pages. Architectural sketches and diagrams illustrating his thesis have served as the basis for the artist's drawings reproduced here.

Expedition Planned, Too

In order to visualize a Martian base, Moffett realized at the outset, he would have to know how many men would make up a landing party on the planet, how long they would stay there, and exactly what they would want to do during their stay. So he and his scientific advisers found themselves the planners, not only of the base—but also of the expedition itself.

Scientific discoveries will be the ob-

This Gun Shoots Atomic Shells

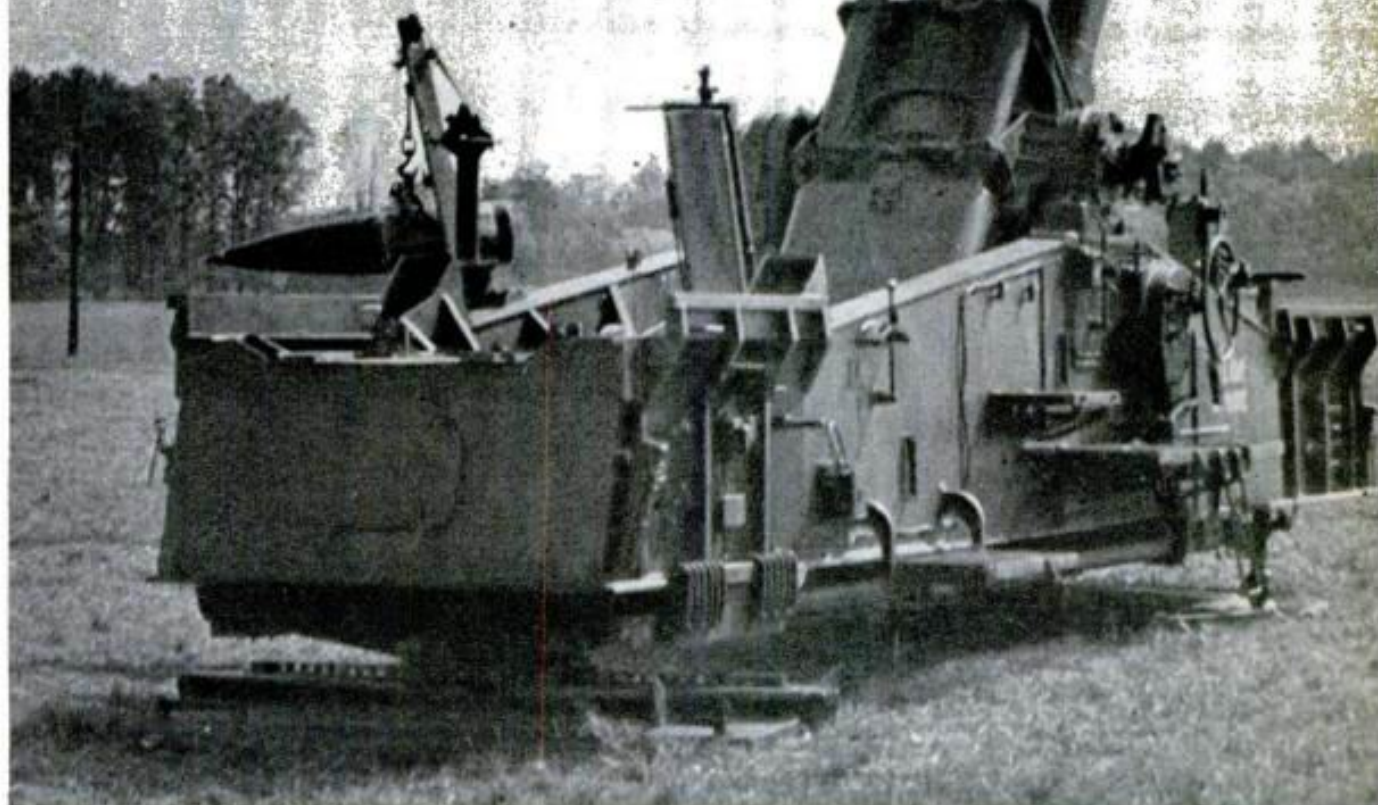
Cradled between two huge tractors, Army's most destructive weapon rocks into position fast.

PSM PHOTOS BY W. W. MORRIS

THE wraps are off the U. S. Army's atomic cannon, the biggest and deadliest of ground weapons. It can accurately blast a target at 20 miles in any weather, day or night, when atom-loaded airplanes could not.

Called the 280-mm. T131 (nickname: Ter-mite), it weighs 85 tons and measures 84 feet long complete. Yet it can go almost anywhere, travel 35 miles an hour on the road and get ready to fire much faster than other big guns. Two giant six-wheel tractors cradle the gun between them, zigzagging the rocking, pitching carriage across rough ground like some fantastic reptile.

Pictures on the next two pages show how the gun will fire an atomic shell.—Martin Mann.





1 HEAD AND TAIL TRACTORS haul atom gun as completely assembled unit, nearly ready to fire. They can run in line, turn to carry gun sideways and turn corner in 28-foot street.



4 HAND JACK shifts center of gravity of gun unit so that it balances on ball-in-socket center support (left foreground), lifting rear. It can then be rotated to any angle.



2 INTERCOM CONNECTS DRIVERS, who steer independently. Front driver can control both throttles and brakes, however. Smooth-riding tractors have automatic transmissions.

3 WINCH EXTENDS AND RAISES GUN after hydraulic pistons lower carriage to ground. Then tractor pulls off. Muzzle is shown below between fork on tractor that fits ways on gun.





5 **BALANCE IS SO DELICATE** that crew (four men are enough) can swing carriage to point the right way. Jack then lowers rear end and hand gear makes final traverse setting.

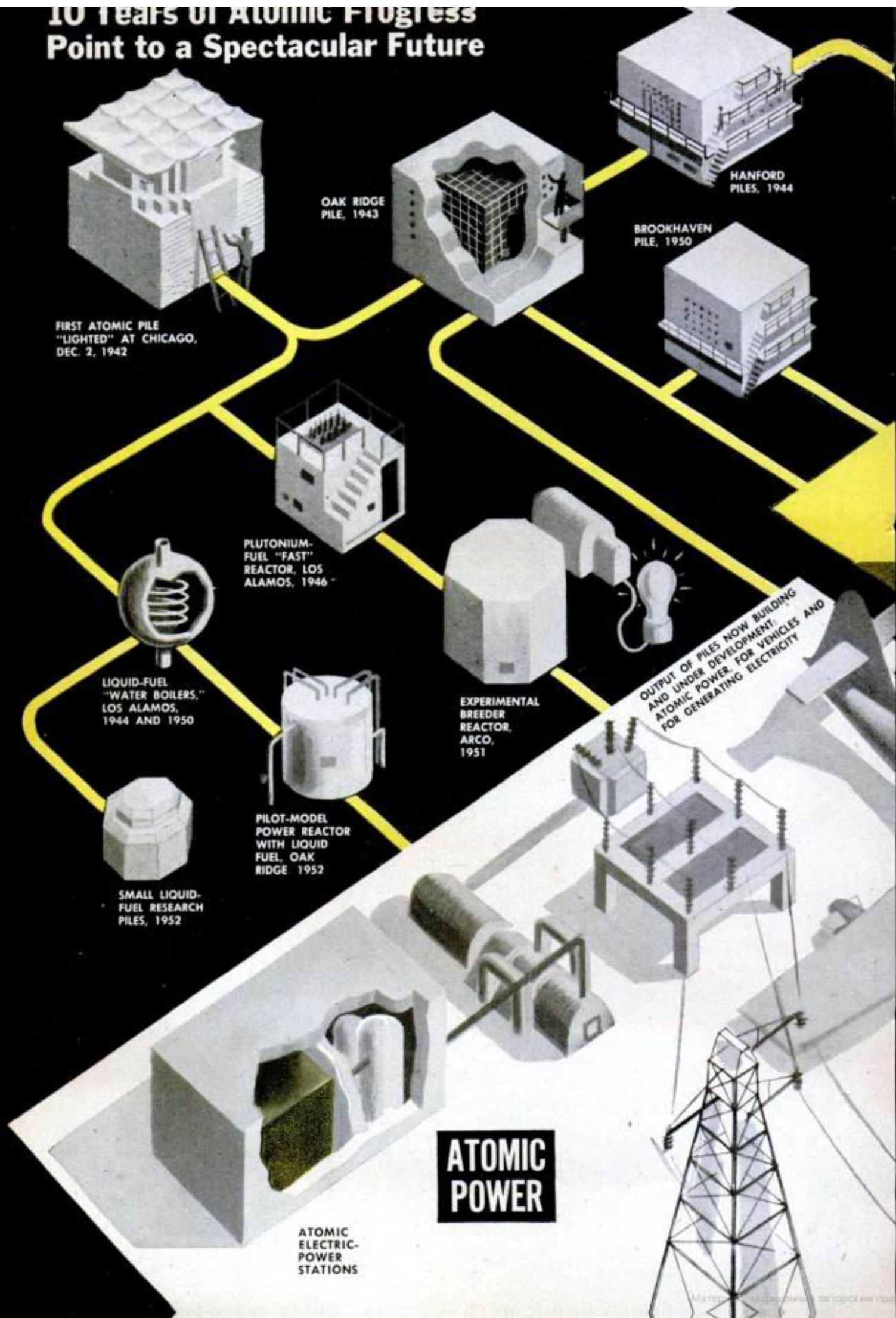


6 **SHELL IS LIFTED** by winch, then rammed into breech hydraulically. High-explosive shell weighs 600 pounds. Atomic shell is secret, but must look much like non-atomic one above.



7 **CAR-R-ROOM!** You know it when this popgun goes off. Actually, noise and shock wave from this shot—a demonstration that sent a dummy slug out over Ordnance Corps' Aberdeen Proving Ground—were milder than most press observers expected.

10 Years Of Atomic Progress Point to a Spectacular Future



OUTPUT OF
HANFORD PILES:
PLUTONIUM FOR
ATOMIC WEAPONS

FIRST
A-BOMBS

TACTICAL
OR "BABY"
A-BOMBS

MORE POWER-
FUL A-BOMBS

GUIDED A-
MISSILES

ATOMIC WEAPONS

OUTPUT OF OAK RIDGE
AND BROOKHAVEN PILES
RADIOISOTOPES FOR USE
IN THERAPY AND
AS TRACERS

RADIOACTIVE
INJECTIONS
TO TREAT
DISEASE

VIAL OF
RADIOISOTOPE
AS SHIPPED
TO USER

ATOMIC
ARTILLERY

MEDICINE AND RESEARCH

EXPERIMENTS WITH
RADIOACTIVE TRACERS

ATOMIC
AIRPLANES

ATOMIC
AIRCRAFT
CARRIERS

ATOMIC
SUBMARINES

NOVEMBER 1952 101



Triple-Decker to Ferry Cars and Passengers

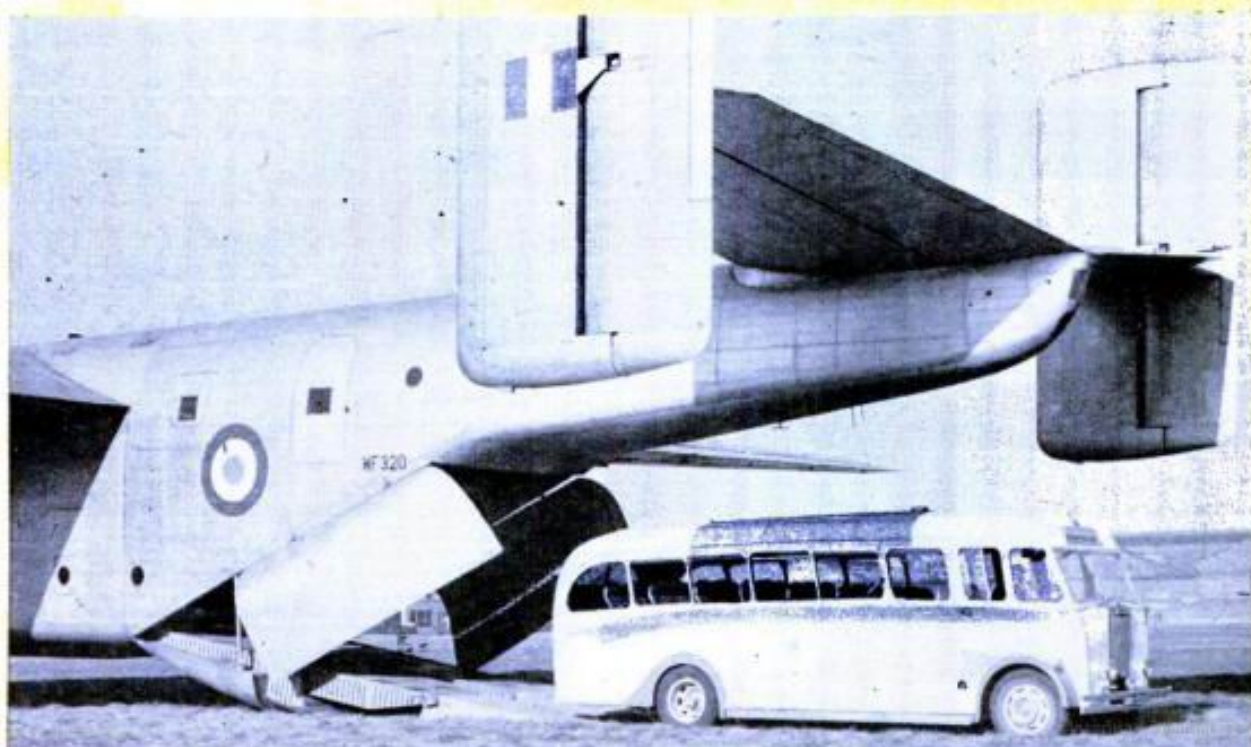
Redesigned model of Europe's largest air freighter will carry autos in aerial "hold" and passengers in a luxury tail cabin.

A BUILT-IN elevator will raise automobiles to the upper fuselage deck of a new version of the Blackburn Universal Freighter now being built in England. The two cargo decks will hold six to eight cars, depending on size. There also will be room for motorcycles and bicycles at one side of

the lower deck. The upper deck in the tail, reached by a staircase, will accommodate 42 passengers. With this arrangement, it is claimed that the 55-ton plane can carry three times its present payload. The 180-mile-an-hour Freighter can land on and take off from grass fields.



Clamshell doors and loading ramp of the present version of the Freighter are shown below.



Commuters May Take a

They'll Whistle Into Ports Like This One in London If Progress Continues.

COMMUTING by helicopter may be coming for suburbanites here and abroad. Cheered by the windmills' military success in Korea, 'copter enthusiasts are busy planning ways to use them in cities.

In England, which probably has more regular passenger-helicopter routes already than any other country, a heliport is proposed for the heart of London. It would be built partly over the busy Charing Cross railway station and extend over the River Thames, as shown in the drawing at right.

Complete with Radar

Plans call for an installation as complete as any large airport, including radar aids for landings in London's pea-soup fogs. Elevators would lower helicopters to a hangar deck for servicing. The location was chosen because it provides unobstructed approaches over the river as well as excellent connections to every part of the city by bus, subway and railway (inset, upper right).

The helicopters seen in the drawing represent two types now flying in England. One leading rotary-aircraft builder, Westland Aircraft Limited, also has several advanced models on the drawing boards: the W.80, a 24-passenger helicopter designed for intercity travel and a larger 35-passenger W.81 powered by a twin Mamba gas-turbine unit. Still another, designed for the military at present, would carry 100 troops. With jet power in the tips of a three-bladed rotor, the craft could be redesigned for civilian use.

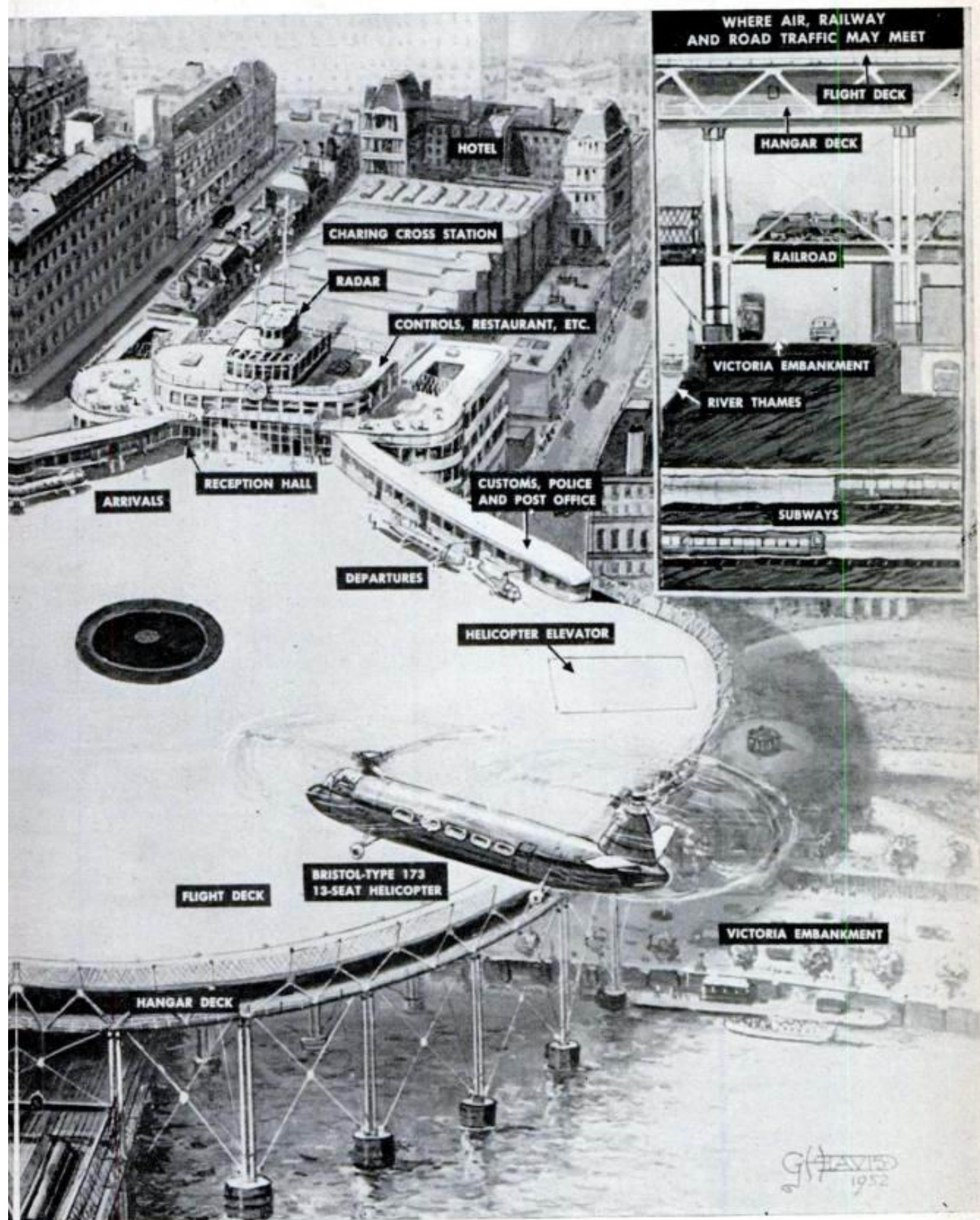
New York to Get 'Copter Service

New York also is preparing for hovering helicopters. For some time there has been local air-mail 'copter service out of Los Angeles and Chicago. Recently the Civil Aeronautics Board authorized a shuttle service between New York's big airports.

Looking for a mid-Manhattan landing site, engineers hit on a Hudson River pier that was being reconstructed. By adding a substructure of watertight concrete boxes, it could serve as heliport and ship dock.



Helicopter to Work Soon



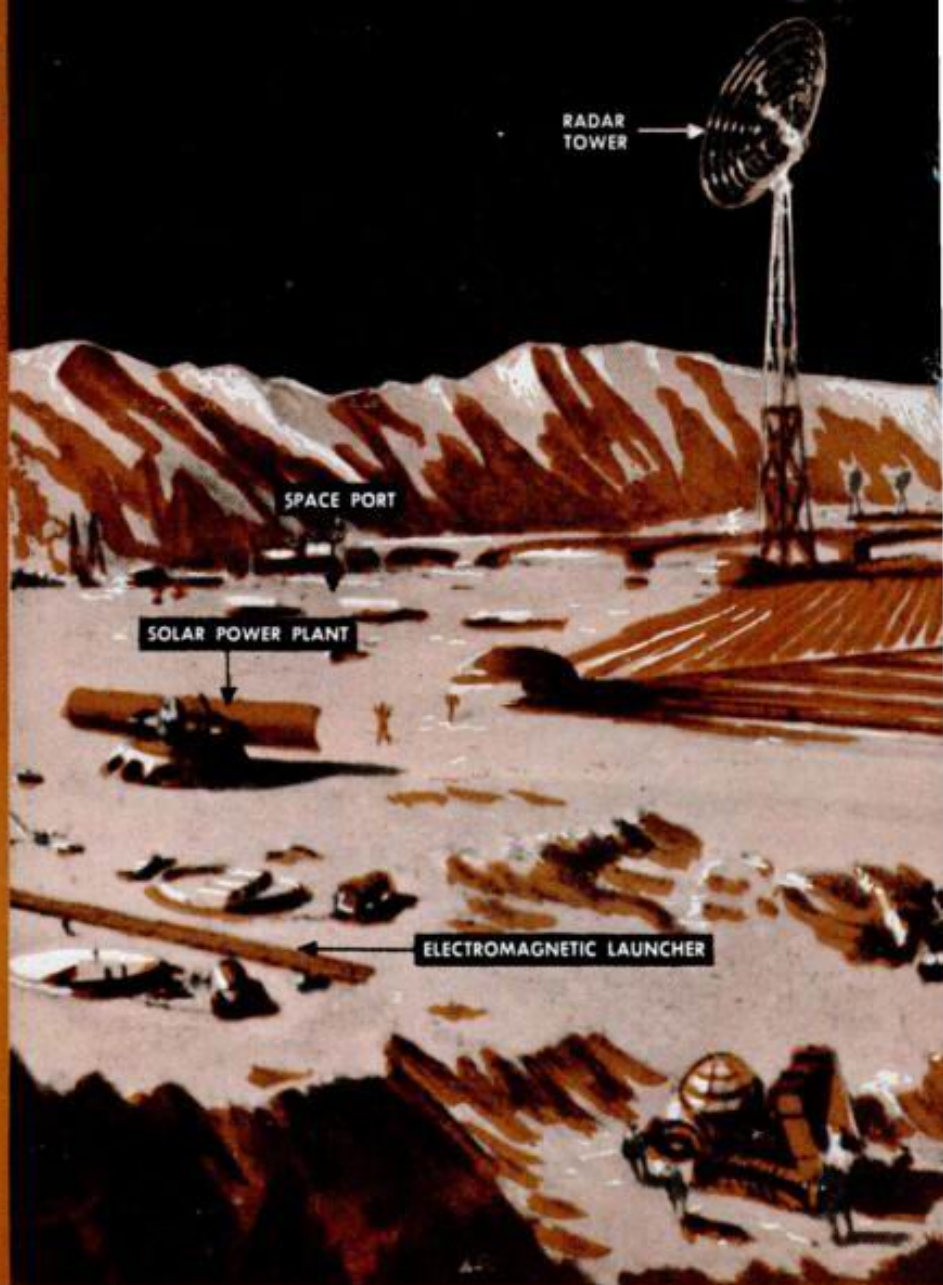
LUNAR BASE

THE experts no longer argue *whether* men will someday ride rockets into outer space. They've moved on to planning *how*.

But *where*? First of all, obviously, to the Moon, which is only a hundredth as far away as the nearest planet: some 240,000 miles—an easy five-day trip—compared with 26,000,000 miles to Venus.

"The human race is remarkably fortunate," writes Arthur C. Clarke, chairman of the British Interplanetary Society, "in having so near at hand a full-sized world with which to experiment: before we aim at the planets, we will have had a chance of perfecting our techniques on our own satellite."

In the article that follows, Mr. Clarke discusses what we'll do when we get there. It is condensed from his new book, *The Exploration of Space*, to be published this month by Harper & Brothers.



What Will We Do

Chairman of British Interplanetary Society tells how explorers

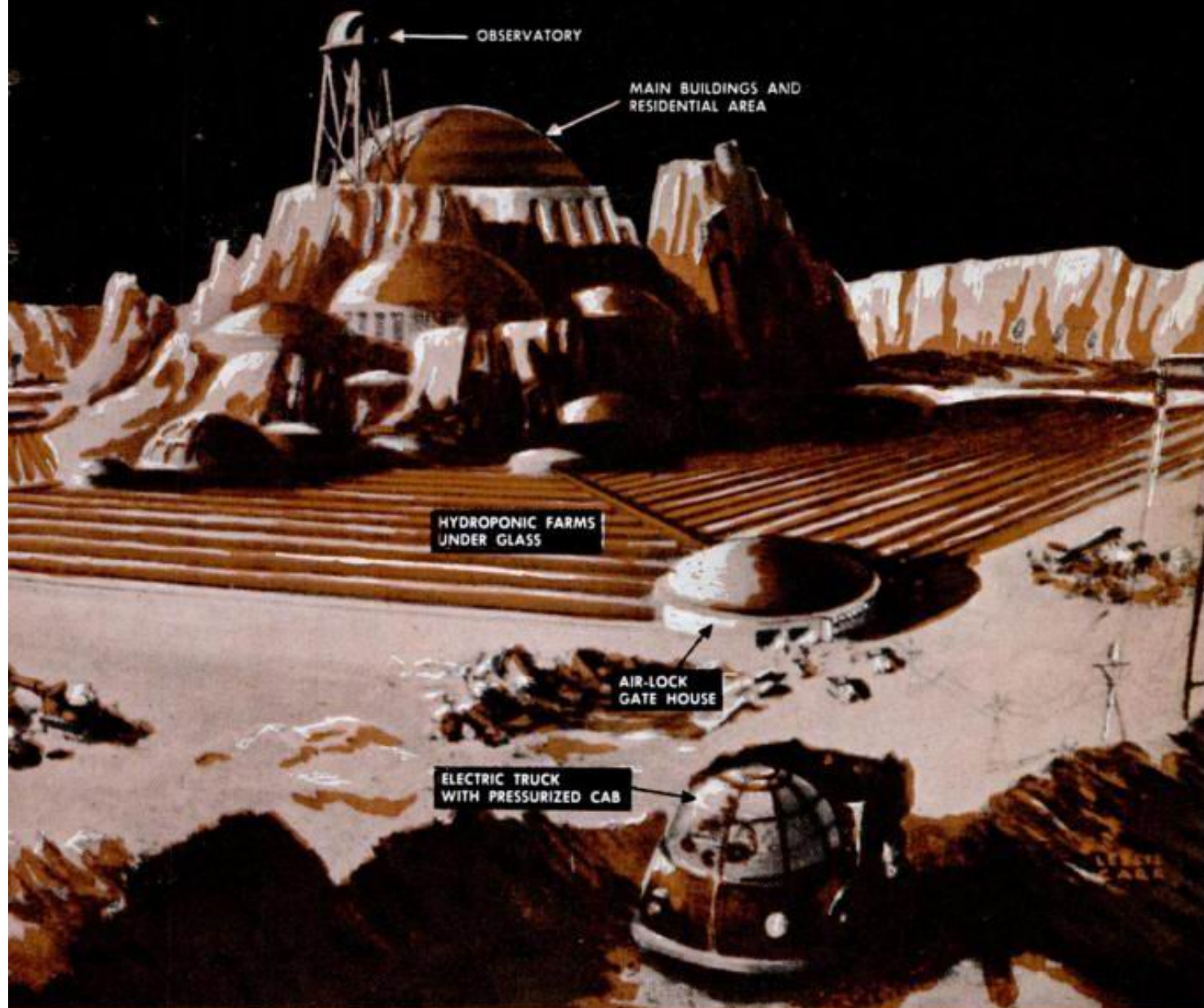
By Arthur C. Clarke

Copyright, 1951, by the Author

TODAY we can no more predict what use mankind may make of the Moon than could Columbus have imagined the future of the continent he had discovered. Nevertheless, it is possible to foresee certain lines of development which appear likely as soon as we have reached the Moon, and we can also discuss, in general terms, the problem of making it habitable.

The things we are to discuss now will not happen quickly, and some will remain unaccomplished for centuries. But in the end they will be achieved—unless better, perhaps more fantastic solutions are found.

The first lunar explorers will probably be mainly interested in the mineral resources of their new world, and upon these its future will very largely depend. If we are to set up permanent colonies, it is essential to discover oxygen, water and materials from which food may be obtained.



Drawings copyrighted, 1951, by Temple Press, Ltd., London

with the Moon?

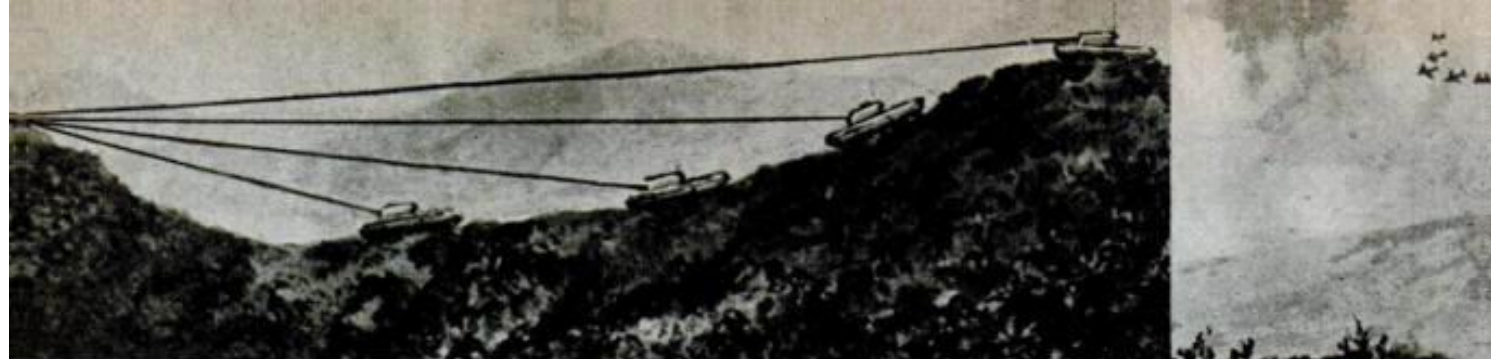
in refrigerated suits will expand igloos into a pressurized city.

With the spaceships themselves acting as bases, the area around each landing point will be carefully prospected by men wearing space suits. In the space suit, because there is no pressure outside, there will be a very considerable force tending to make the suit rigid, like an inflated tire, thus spread-eagling the unfortunate occupant. This has already been encountered in the design of suits for high-altitude flight.

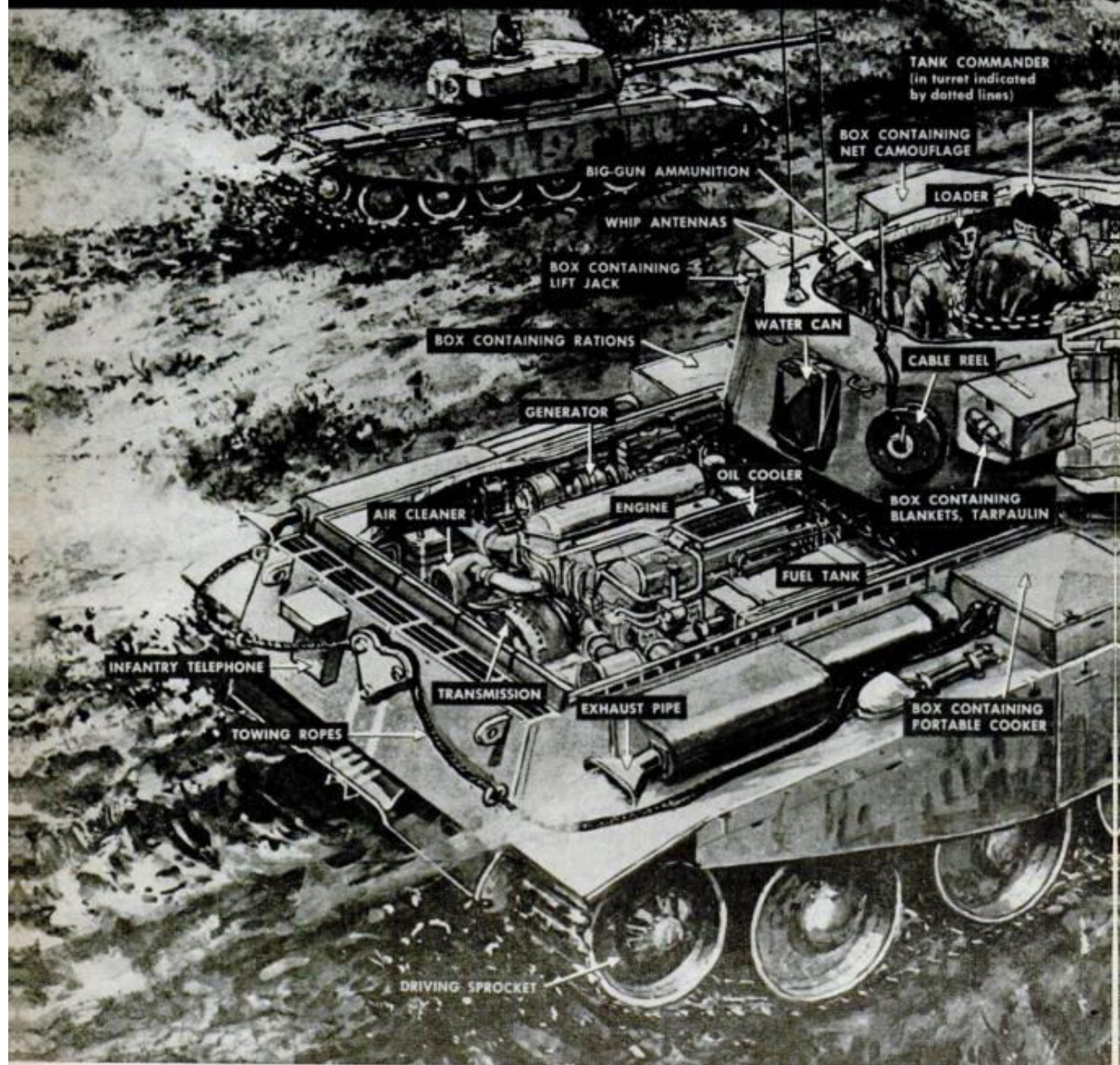
For this reason, space suits may have to be fairly inflexible structures, with articu-

lated joints at elbows, knees, etc., to allow for the necessary movements. They would thus resemble suits of armor, and might be just about as comfortable. Luckily the low gravity would simplify the problem of weight, though it must be remembered that the *inertia* would be unaltered. (On the Moon it would be six times easier to lift a sledge hammer than on the Earth—but it would be just as hard to swing it.)

If even this sort of construction does not enable reasonably form-fitting space suits

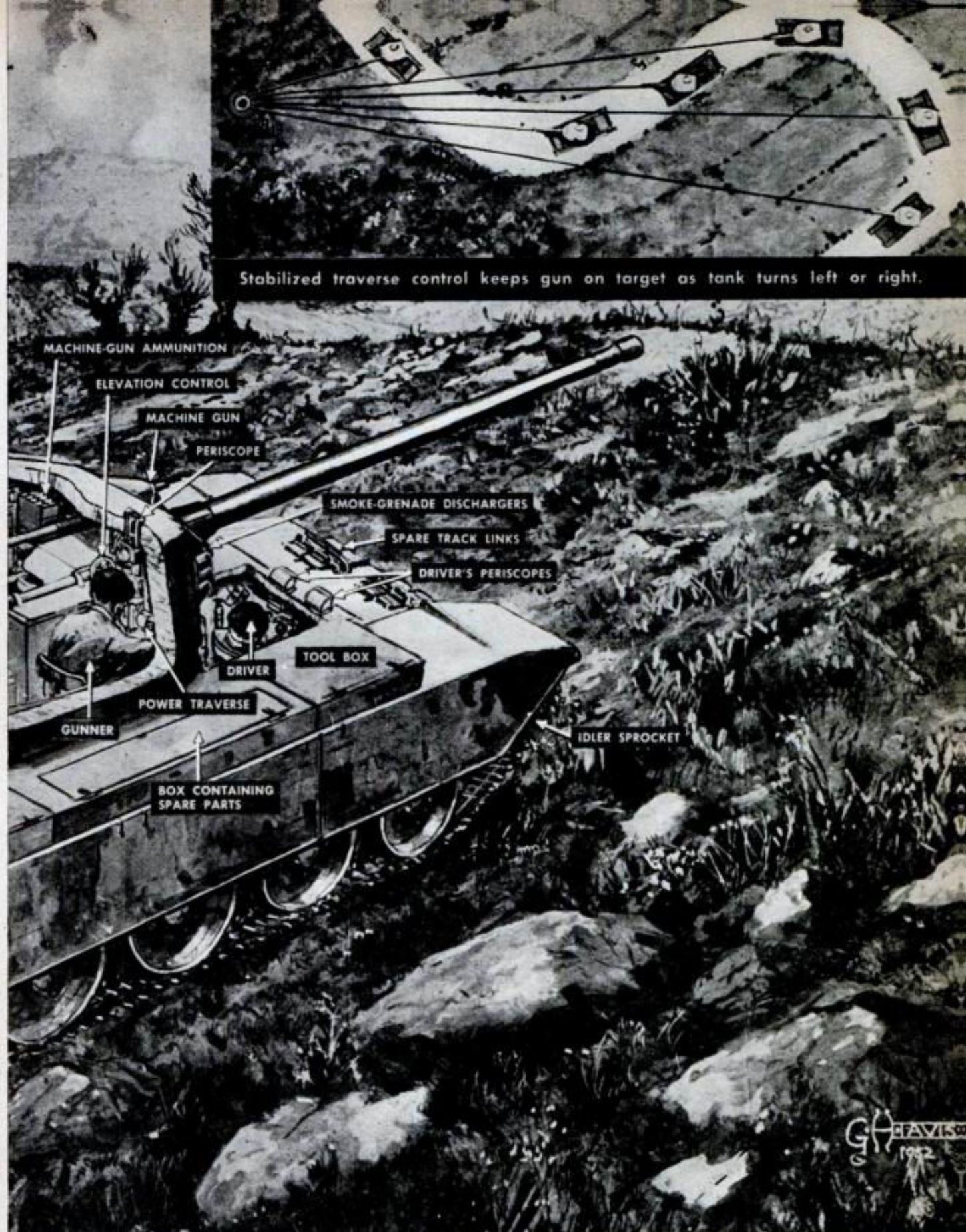


Stabilized elevation control keeps gun on target as tank goes up or down hill.



Big British Tank Aims on the Run

THE Royal Armoured Corps' new 48-ton Centurion tank, sketched in action by a British artist, is truly a land battleship: Like a warship's big guns, its rapid-firing 20-pounder (about 90 mm.) is automatical-



Stabilized traverse control keeps gun on target as tank turns left or right.

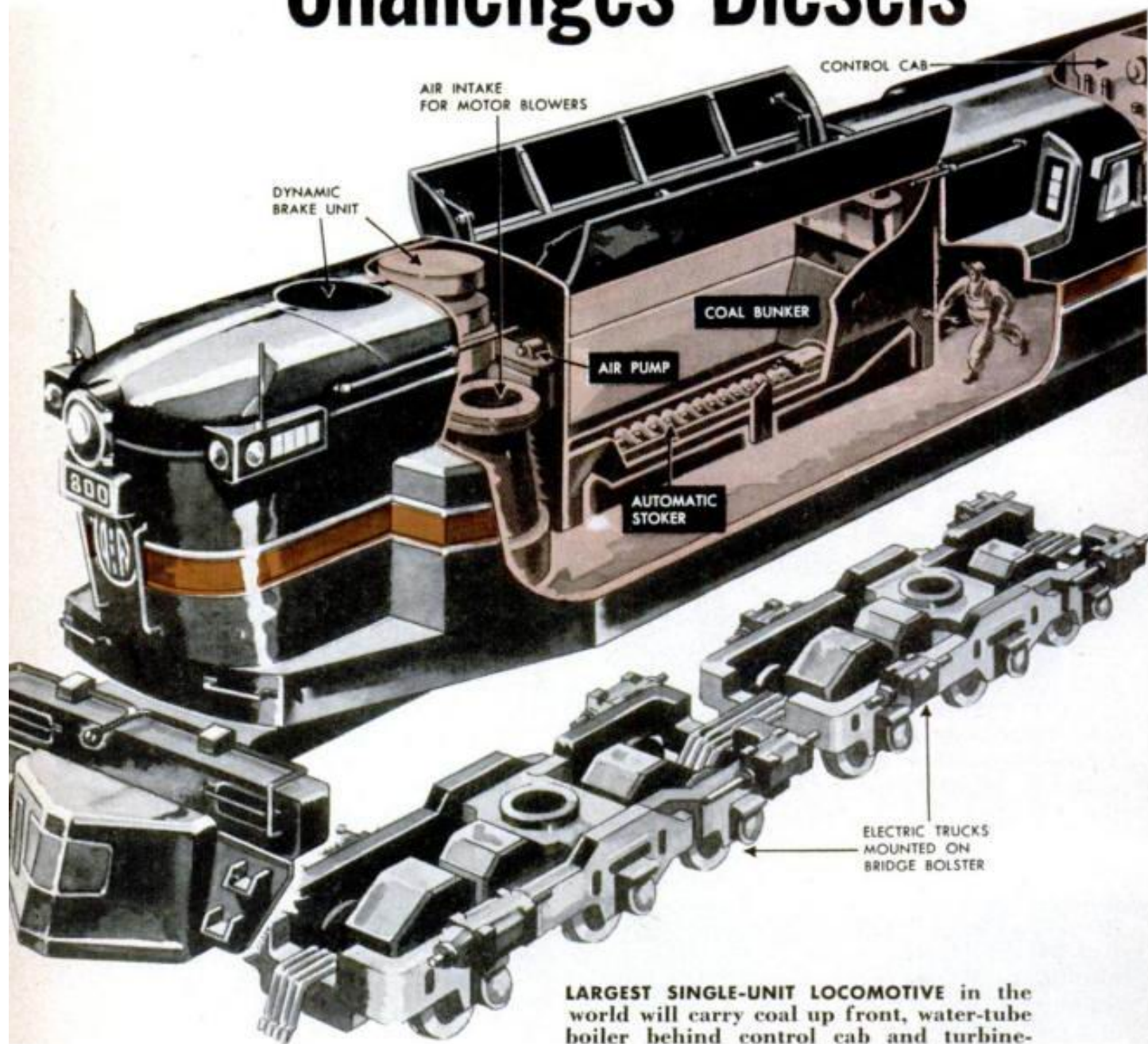
ly kept trained on target—no matter how the huge tank turns and bobs over rough terrain.

Successfully battle-tested in Korea, the Centurion also mounts a 7.92-mm. machine gun in its power turret, carries a crew of

four and has a top speed of 20 m.p.h. Its hull is 25 feet long and 11 feet wide. The 12-cylinder engine develops 640 horsepower.

Not shown in the sketch: the Centurion's outlet for an electric razor.

New *COAL LOCOMOTIVE* Challenges Diesels



LARGEST SINGLE-UNIT LOCOMOTIVE in the world will carry coal up front, water-tube boiler behind control cab and turbine-driven generator at rear.

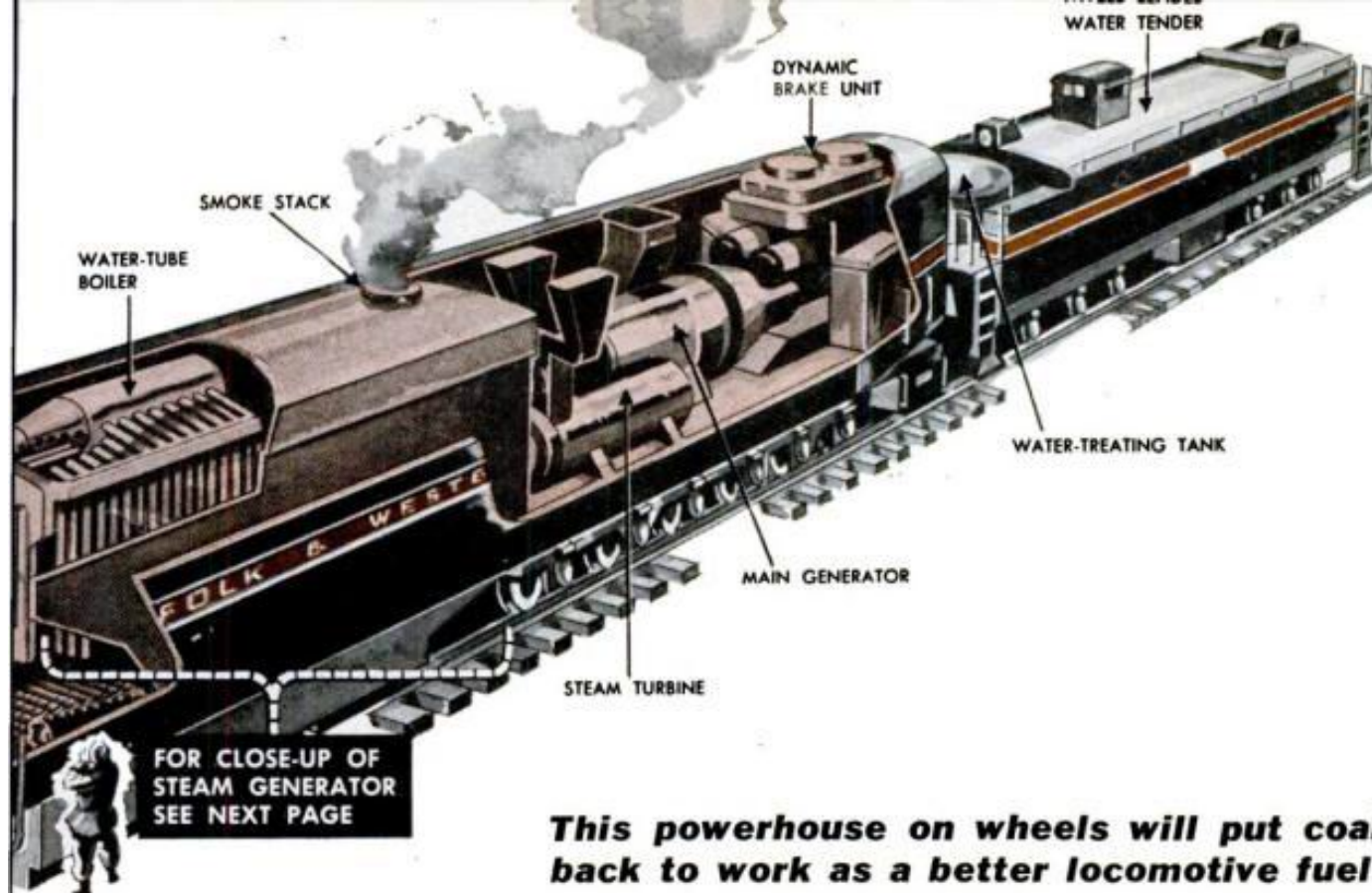
By **Henry B. Comstock**

SOMETIME next September, engine crews and technicians of the Norfolk & Western Railway will put the world's largest single-unit locomotive through its paces. Officially it will be classed as a coal-burning

steam-turbine-electric. But already the men who roll America's heaviest tonnage up and down the coal-lined canyons of West Virginia are calling the coming giant "Jawn Henry."

The legendary Jawn is to railroading what Paul Bunyan is to the lumber industry and,





This powerhouse on wheels will put coal back to work as a better locomotive fuel.

like him, this black behemoth defies comparison. Measuring 161 feet between couplers, it will weigh in the neighborhood of 600 tons and develop 4,500 horsepower.

Up in the control compartment, engineers are going to find 110 years of traditional locomotive design thrown suddenly in reverse. The coal will be out front, stowed under hatches that open and close at the touch of a compressed-air valve. The boiler will be at their backs. Unbelievably, the steam-gauge hand will palsy at the 600-pound-per-square-inch mark. That is twice the pressure of today's huskiest engines.

To pour on the power, there will be no massive throttle arm, hinged from a bracket overhead. A trim controller stand is taking its place. As the stubby lever is eased into Number One notch, a silk-smooth surge of electric current will send Jawn Henry growling out of the yard with a mile and a half of heavily loaded hopper cars behind it.

Where does the *steam-turbine-electric* fit into the over-all motive-power picture?

For years railroad men have known that

electric drive was the ideal way to deliver power to the driving axle. It meant smooth operation and control. It gave an engineman the full output of his machine at starting, and dynamic braking to boot. It was easy on the rails, and shop crews liked its relatively light and standardized running gear.

But the cost of stringing thousands of miles of overhead wire before a single electric locomotive could glide off with a payload scared customers back to the roundhouse. Then the Diesel honked onto the scene, hauling its own generating plant. As a self-propelled machine, it has been selling nationwide electrification on the installment plan.

Diesels Require Costly Duplication

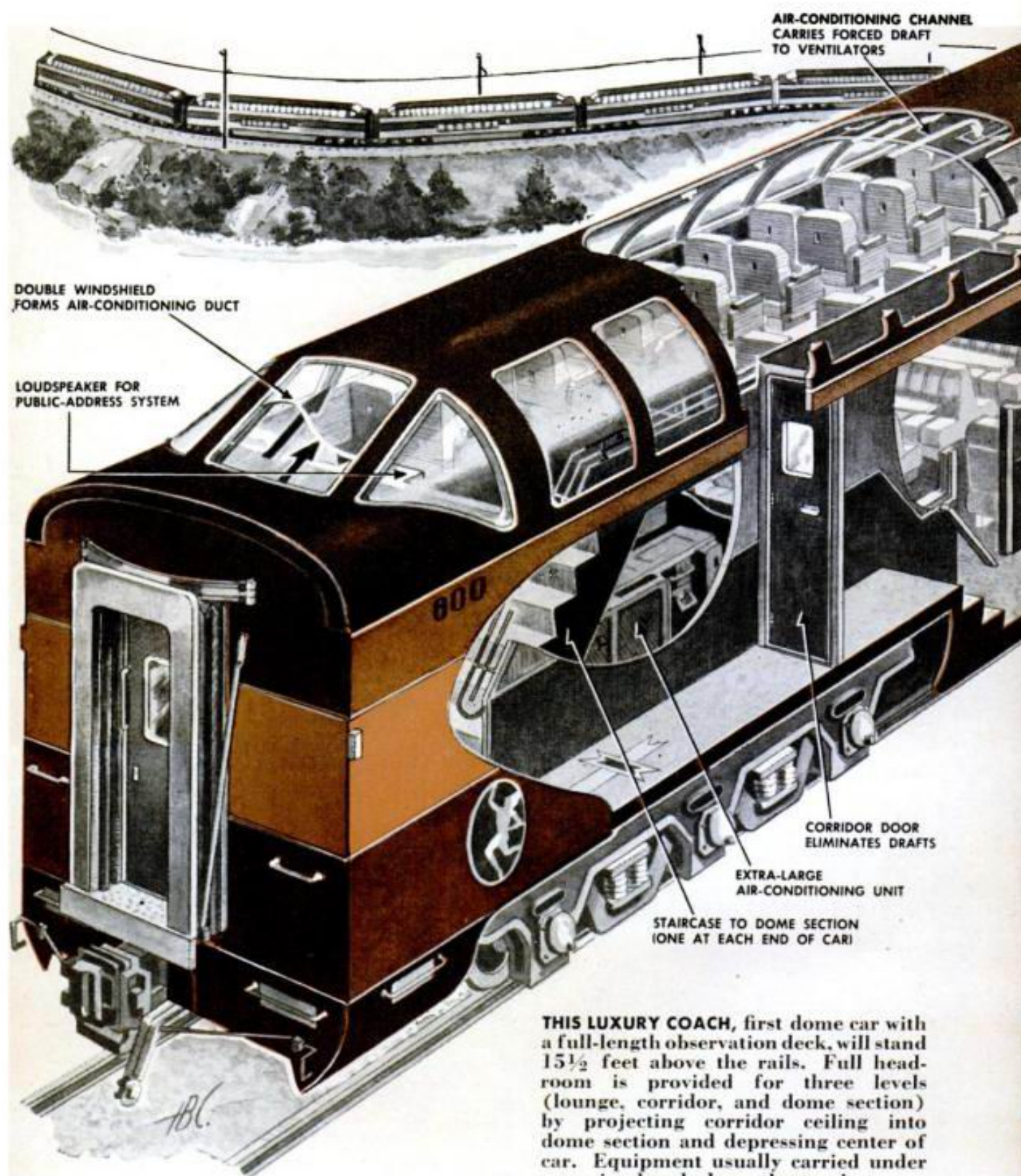
Unfortunately the "carrying charge" is high. Even the largest Diesel engines which can be crowded into a single cab have a relatively small horsepower rating. As a result, a road locomotive may be made up of as many as four units, presenting a costly duplication of equipment. What

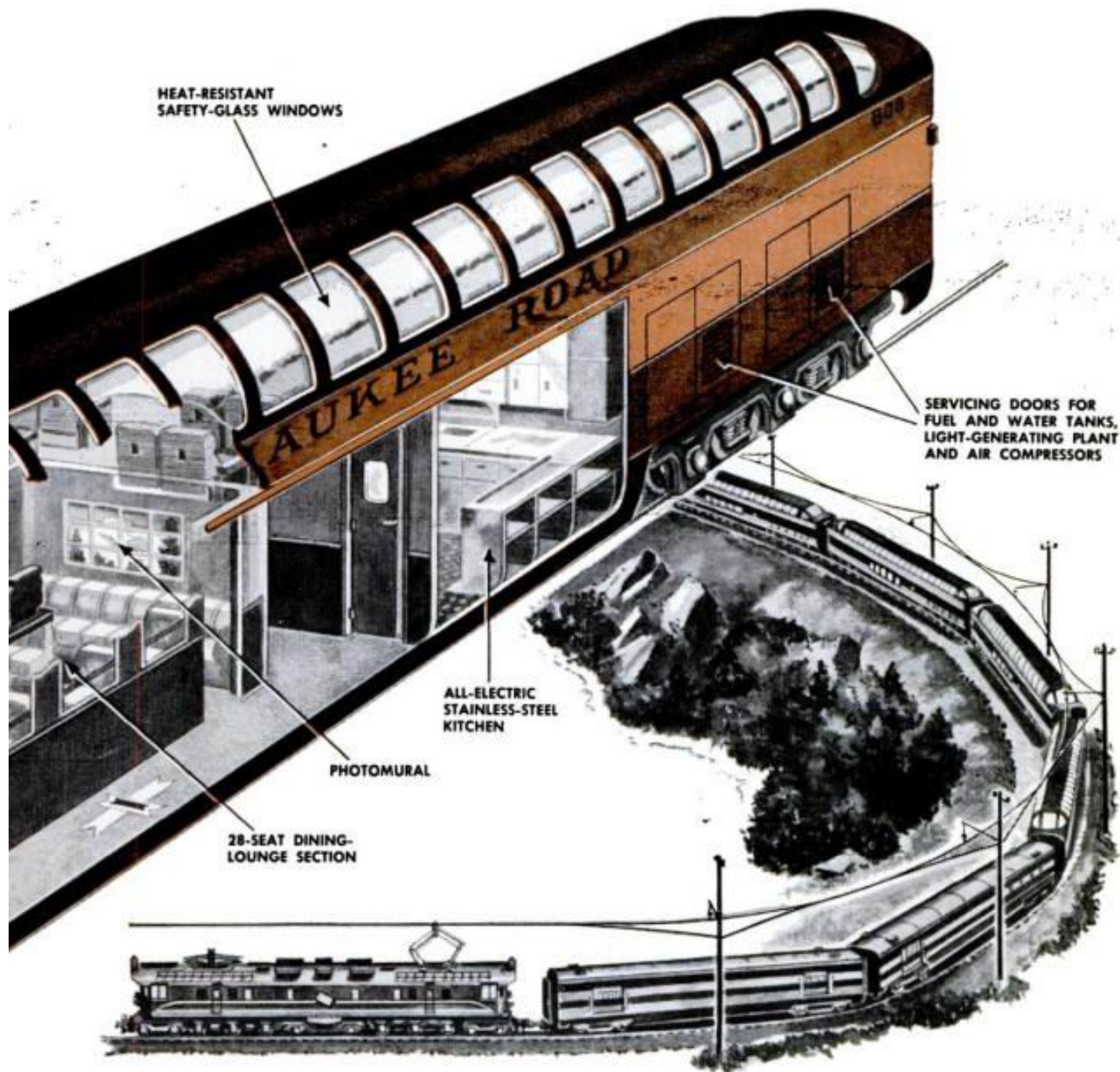
When the crossing lights start blinking for this giant, you might as well cut your ignition and count cars. To find how many cars the locomotive can haul, start with border below and keep going till you come to the caboose . . .



Super Dome Cars

Will Carry 68 Upstairs





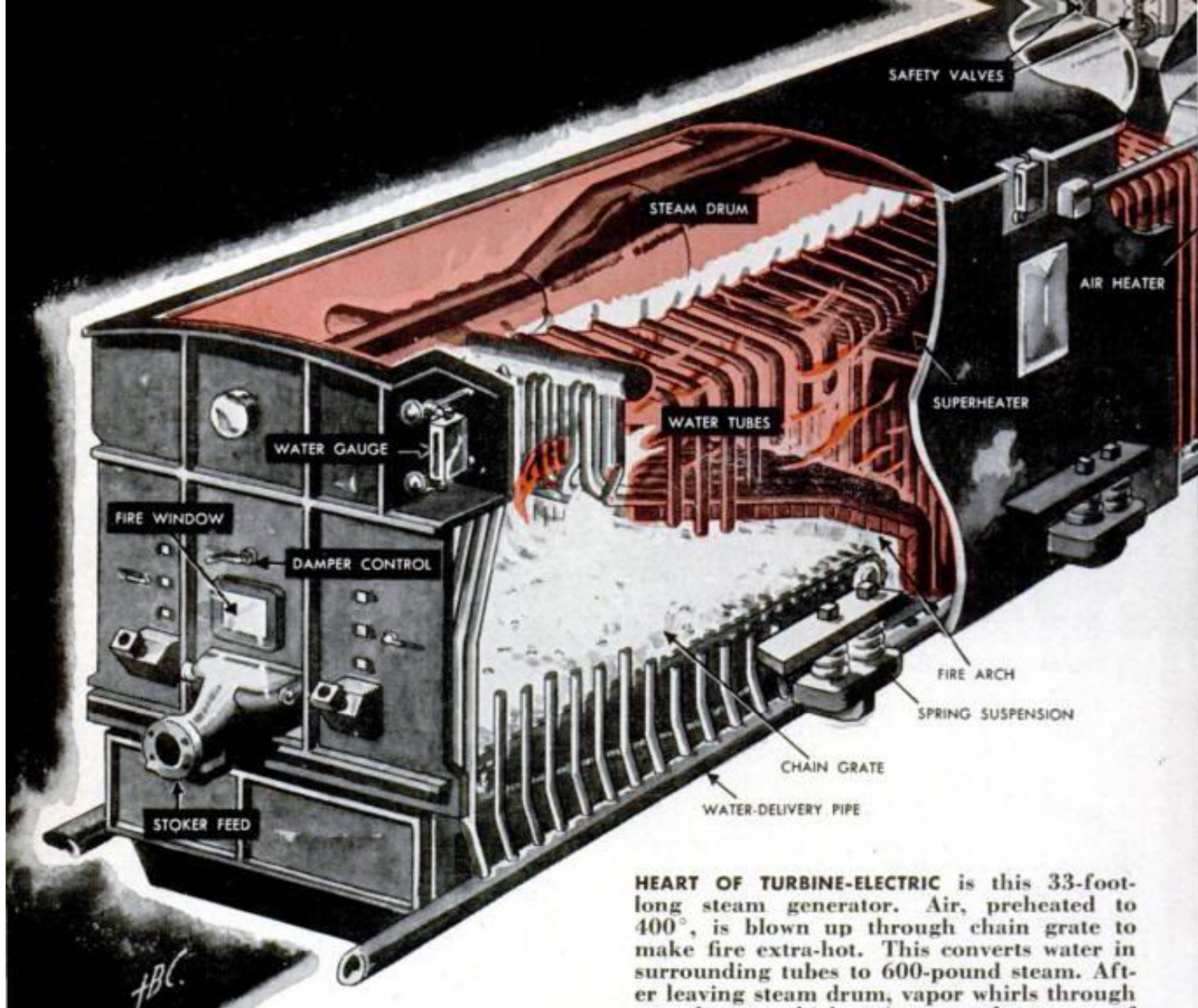
By Henry B. Comstock

RAILROAD travelers like watching scenery from the glass-roofed "dome" cars too much—there isn't enough room upstairs for all who want to sit there. Now a new model will solve this problem with a full-length observation deck providing a seat-with-a-view for every passenger. Downstairs, a luxurious diner-lounge will be served by an all-electric kitchen. Pullman-Standard is making 10 of the cars for the Milwaukee Road.

To beat the summertime heat in the huge double-glazed dome section, an air-conditioning unit twice the size of standard car-cooling plants is being placed in one end section. Cold air will be blasted upward be-

tween two panes of glass forming a double windshield at one end of the car, then carried through a channel in the roof. Outlet ports deliver a controlled supply at intervals along the 73-foot glass top.

Sky-gazers will have little to fear from falling rocks and ultraviolet rays. The three-by-five-foot, curved dome windows are to be made of half-inch-thick, tinted safety glass. Through them, travelers will be treated to a bigger and better view of the scenery—the Bitter Roots, Rockies and Cascades from the Olympian Hiawatha, to which six of these cars will be assigned; and the upper Mississippi Valley from the Morning and Afternoon Hiawathas, each of which will rate two cars. Loudspeakers will announce points of interest. **END**



HEART OF TURBINE-ELECTRIC is this 33-foot-long steam generator. Air, preheated to 400°, is blown up through chain grate to make fire extra-hot. This converts water in surrounding tubes to 600-pound steam. After leaving steam drum, vapor whirls through superheater which wrings out last trace of moisture. Then it enters turbine engine.

is needed is a more powerful and rugged engine—one which can drive a larger generator and boost the performance of a single locomotive unit.

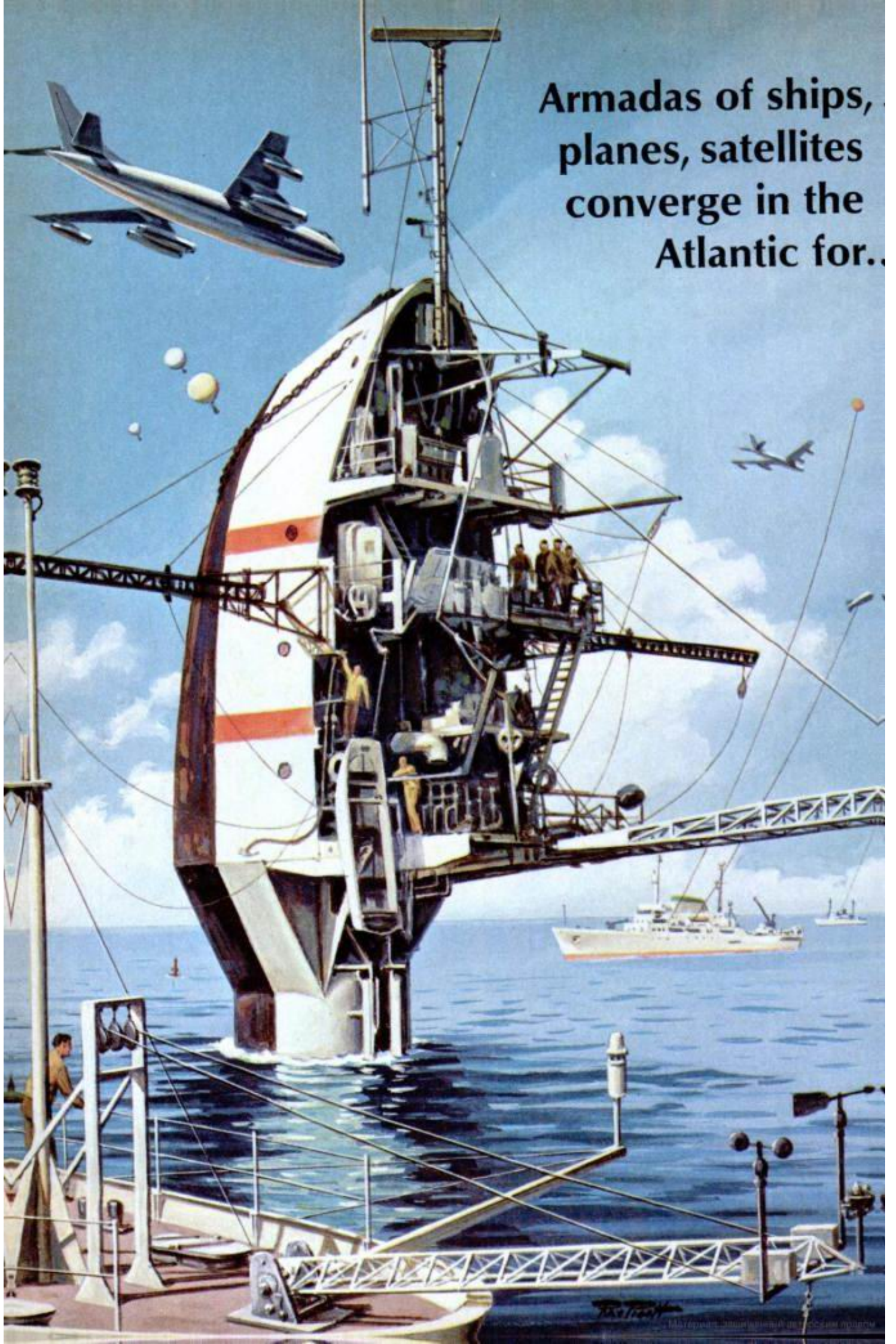
Norfolk & Western officials believe that this giant of theirs will have that engine. But they are not going out on a limb with superlative claims. They know that every other steam-turbine locomotive built to date has long since been cut up for scrap. They are also convinced that they know the reason why. The trouble, they say, has nothing to do with the turbine itself. The big problem is to design the right steam generator. No conventional engine boiler can satisfy the turbine's greedy appetite without running up prohibitive fuel costs. Marine en-

gineers recognized this fact long ago and turned to high-pressure flash- and water-tube jobs. They work to perfection in a ship's hull. But out on the railroads, track shocks and the skewing action of an engine frame can turn the best seagoing boiler into a mass of leaking tubes and crumbling fire clay.

Working with Babcock & Wilcox engineers, N & W has analyzed these damaging stresses, discarded the flash-boiler design, and come up with a water-tube steam generator. This 33-foot-long unit is now under test and gives every indication of having what it takes to stand the gaff.

There will be nothing complicated about the operation of either the boiler or the

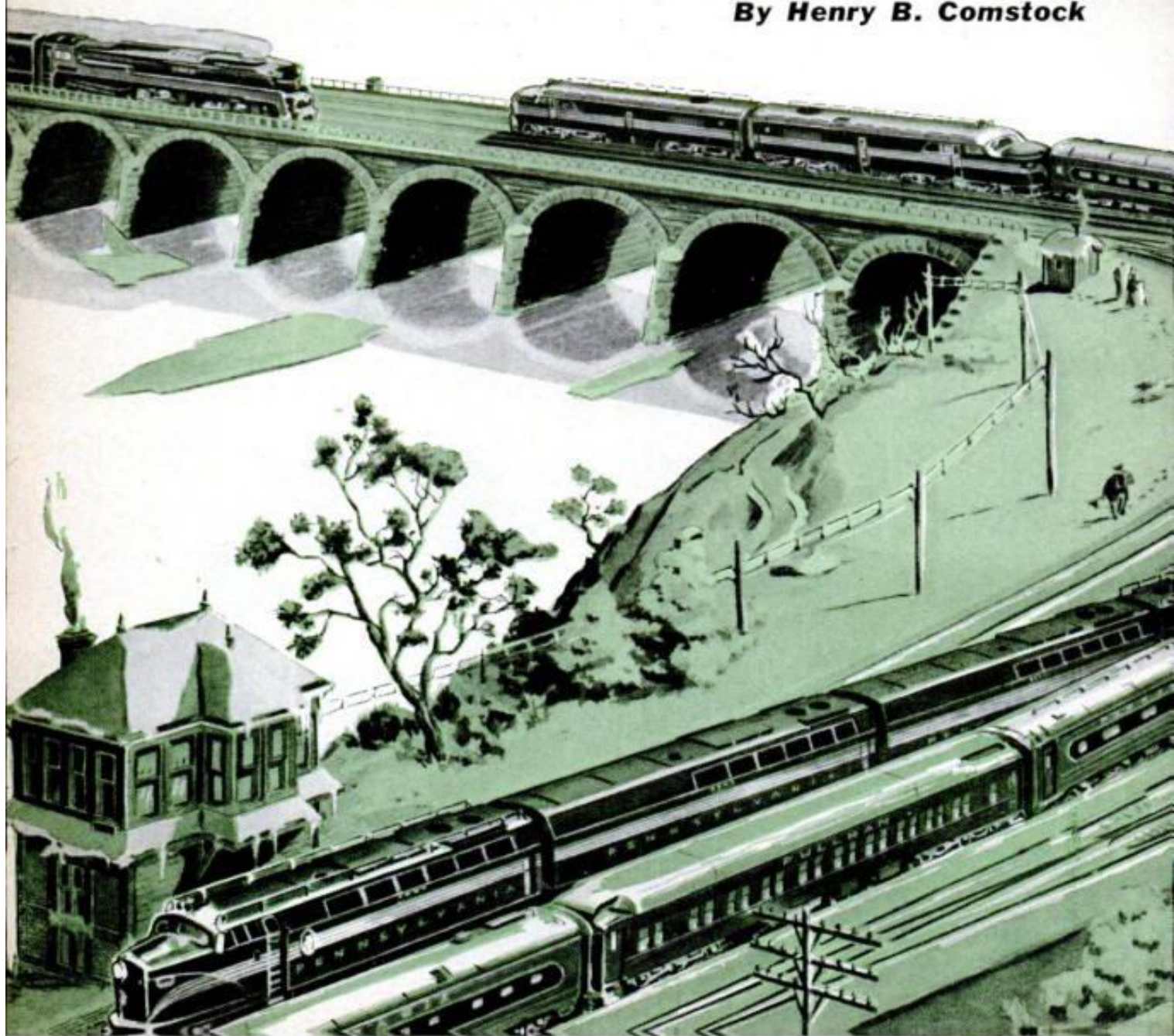
**Armadas of ships,
planes, satellites
converge in the
Atlantic for..**

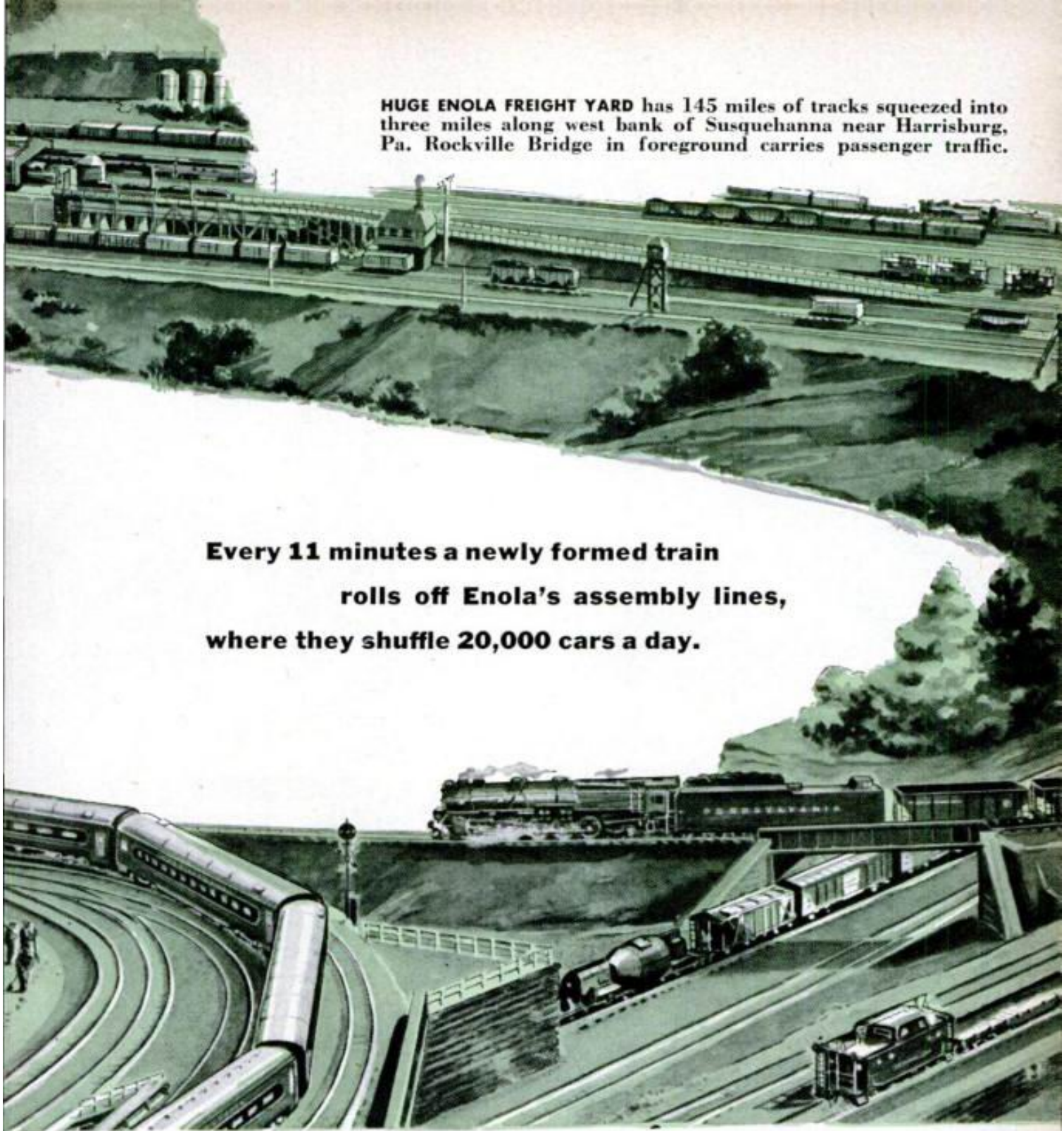




World's Fastest Freight-Train Factory

By Henry B. Comstock





HUGE ENOLA FREIGHT YARD has 145 miles of tracks squeezed into three miles along west bank of Susquehanna near Harrisburg, Pa. Rockville Bridge in foreground carries passenger traffic.

**Every 11 minutes a newly formed train
rolls off Enola's assembly lines,
where they shuffle 20,000 cars a day.**

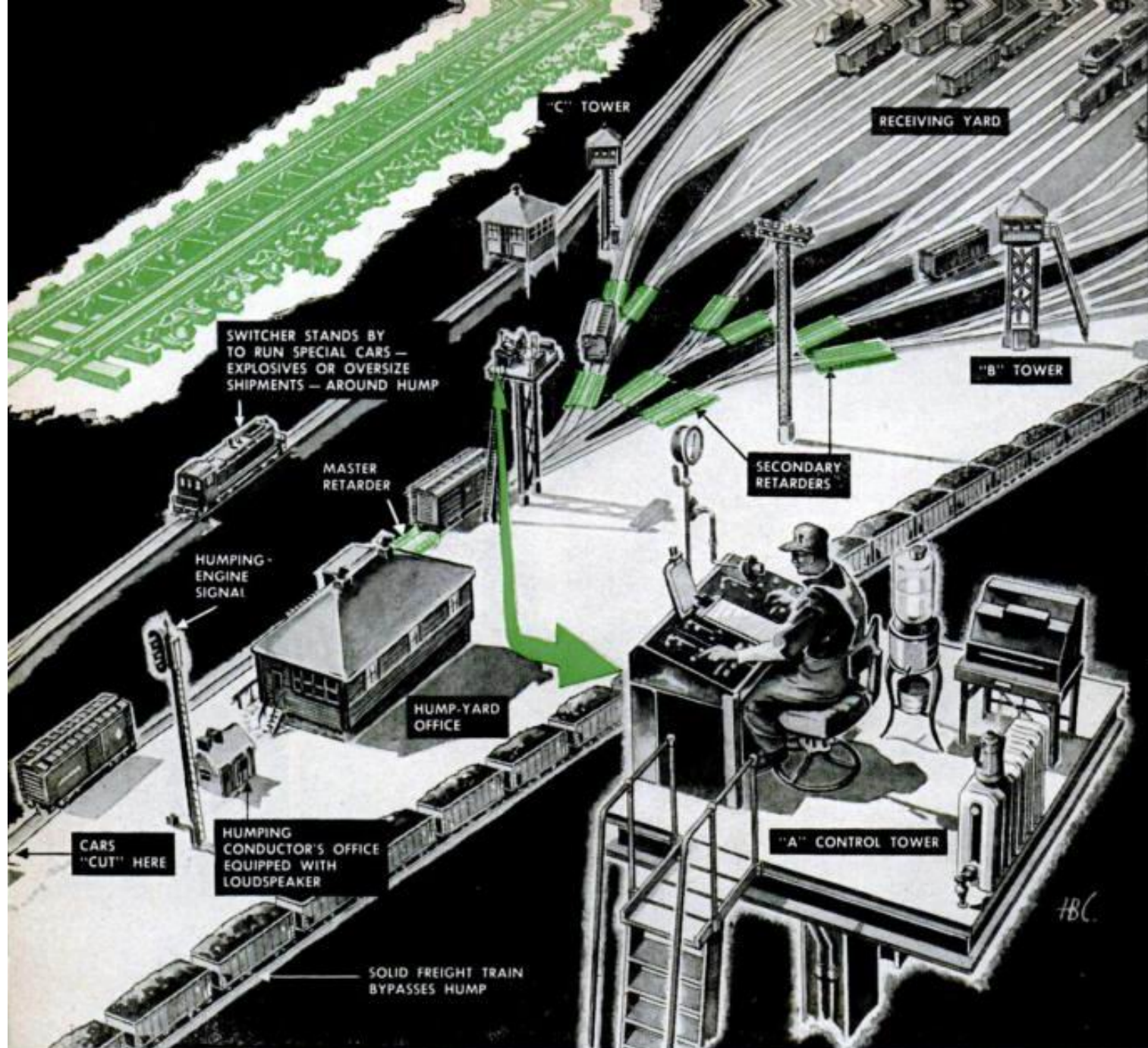
ON THE Pennsylvania Railroad, which owns enough freight cars and locomotives to form a solid train reaching from New York City to Denver, there are 37 major terminals. Each one is a "hot garden," which is railroad lingo for a yard that barrels its traffic through with a minimum of holdover time.

But even on the Pennsylvania, one yard stands out like a circus car in a string of coal hoppers. Its very name, Enola, does double duty. Read it backwards and it spells *alone*. PRR officials will tell you that this

huge terminal on the west bank of the Susquehanna River two miles north of Harrisburg, Pa., got its unusual name, not from its once-isolated location, but in memory of a division superintendent's daughter.

If so, the lady would hardly recognize her namesake today. For Enola's original 12 tracks, laid out in 1902, have now grown into 145 miles of terminal lanes, squeezed between three miles of river front and the concrete ribbons of U. S. Route 11, the Lee-Jackson Highway.

Stop your car at any one of a dozen van-



TOWER MEN control cars rolling down "hump" with "retarders," which grip wheels of pass-tage points along the road and you will see the vast yard spread out beneath you like a model railroader's Shangri-La. There is the inevitable red-brick yard office, a switching plant in itself, with endless reams of paper substituted for cars, and teletype machines for locomotives.

Across the way, a 43-stall roundhouse is sending up enough smoke signals to convince any skeptic that steam engines will not be replaced overnight on the Pennsy. Yet the handwriting is on the wall of the squat Diesel shop beyond. Looking more like a garage than a railroad plant, it inspects and overhauls the gold-striped newcomers on six tracks and at three platform levels.

Upriver, a thousand-foot coal dock is doling out bituminous in 40-ton tender loads; downstream a trim little substation

ing car in pneumatic jaws. Color inset (top left) shows details of this braking device.

does a different sort of fueling job for the big electrics that come humming in from the East. Between the two are acres of car-repair and paint shops, half a dozen control towers, and a tall-stacked powerhouse that compresses enough air in a day to fill all of the truck tires in the State of Pennsylvania.

One look at the layout, with its ceaseless flow of thousands of cars and scores of engines, and you understand the plight of the green switchman who complained: "How can you learn the tracks when you can't see them for the trains?"

"Don't think of this 'garden' in terms of switches and rails," Enola's yardmaster told him. "It isn't a yard; it's a factory. Only instead of turning out washing machines or automobiles, we're building 6,000-ton trains. Up at one end of the three-mile assembly

Models Preview Future Missiles



How tomorrow's guided missiles may look is indicated by these designs from Lewis Flight Propulsion Laboratory, Cleveland. One at left above has twin ramjets on wings; other, sporting tailfirst stabilizers, has ramjet in fuselage. In the photo at right, testers ready a full-scale ramjet for a 20-mile-a-minute "flight" in the laboratory's supersonic wind tunnel.



Smaller Austin Unveiled at London Auto Show



Hit of the British Automobile Show in London this fall was the Austin Seven, which the manufacturer claims is the nearest approach yet made to a perfectly scaled-down big car. Designed primarily for the American "dollar market," the compact four-seater features an all-steel body, foam-rubber cushions front and back, four-speeds-forward synchronized transmission and conservative streamlining.

Powered by a four-cylinder, 30-horsepower, overhead-valve engine, the little sedan weighs less than 1,500 pounds, has a wheelbase of 79½ inches, cruises at 60, and can go 50 miles on a gallon.

Why They Turned Off Niagara's American Falls

Engineers dry up U.S. half of most famous waterfall act—to keep it from going to pieces

By W. STEVENSON BACON
ILLUSTRATIONS BY RAY PIOCH

Visit Niagara Falls this summer and see something really spectacular—a trickle of water running over the dry crest of the famed American Falls.

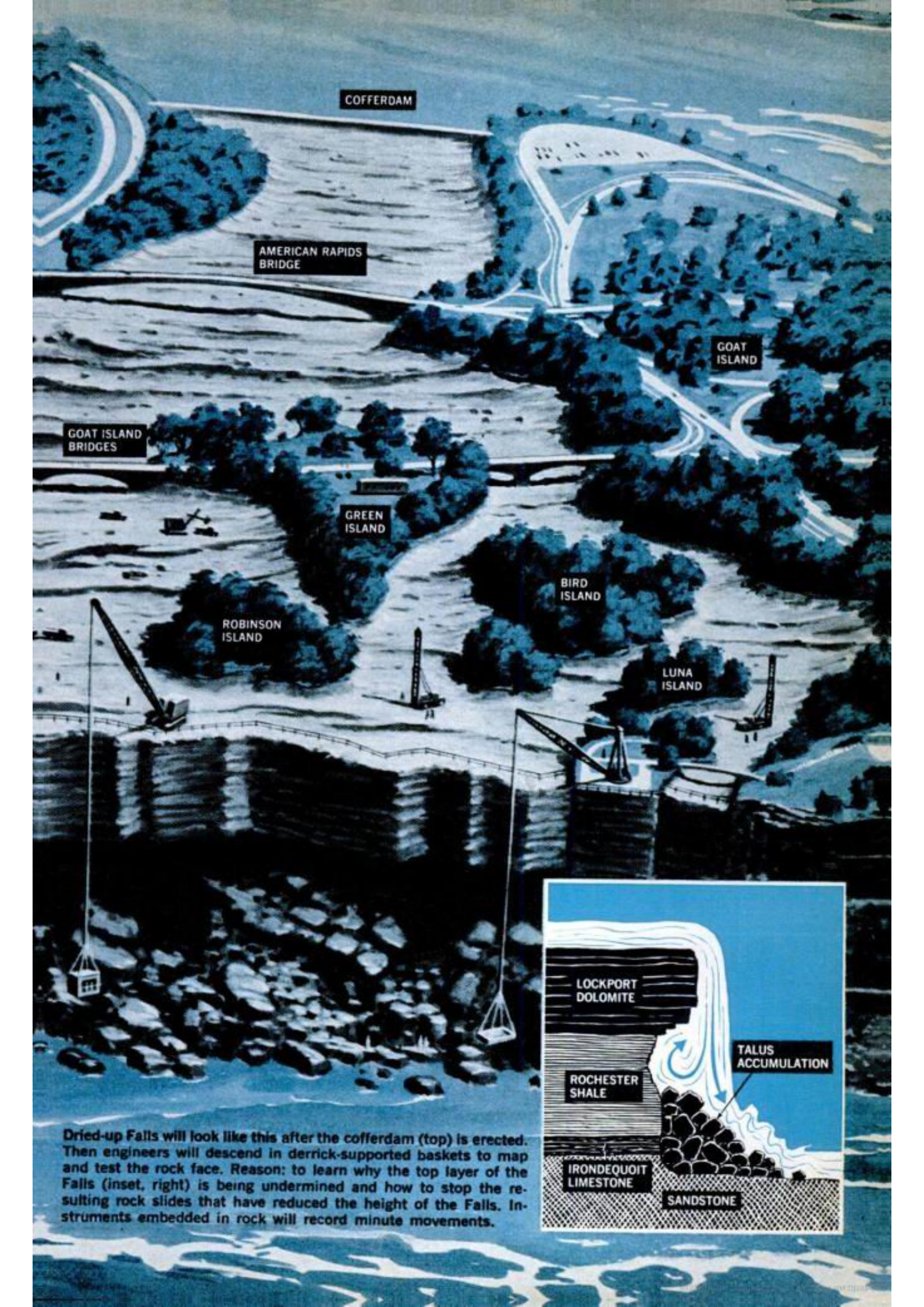
Engineers have shut off the roaring cascade of water to save the U.S. part of this natural wonder, threatened with destruction because of the erosion of the slide-prone rock fall. The end result of this erosion—if left unchecked—will be to reduce the Falls to a jumble of boulders threaded by rapids.

The U.S. Army Corps of Engineers has built a cofferdam from Goat Island to the U.S. mainland to slow the 16,840-ton per-minute waterfall to a tiny trickle. This enables the engineers—suspended in a cage over the crest—to study the face of the Falls. They hope to determine the forces responsible for the mammoth slides that send rock

[Continued on page 199]

Spectacular view of water roaring over the American Falls is familiar to millions of visitors.





COFFERDAM

AMERICAN RAPIDS
BRIDGE

GOAT
ISLAND

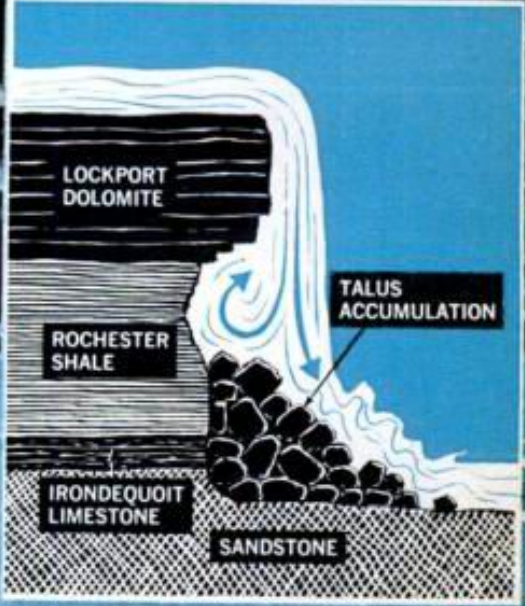
GOAT ISLAND
BRIDGES

GREEN
ISLAND

BIRD
ISLAND

ROBINSON
ISLAND

LUNA
ISLAND



LOCKPORT
DOLOMITE

ROCHESTER
SHALE

IRONDEQUOIT
LIMESTONE

SANDSTONE

TALUS
ACCUMULATION

Dried-up Falls will look like this after the cofferdam (top) is erected. Then engineers will descend in derrick-supported baskets to map and test the rock face. Reason: to learn why the top layer of the Falls (inset, right) is being undermined and how to stop the resulting rock slides that have reduced the height of the Falls. Instruments embedded in rock will record minute movements.

AUTEC: Our Secret Undersea Test Range for Anti-Sub Weapons

A PS reporter takes you on a visit to the Navy base that serves as the "Cape Kennedy" of submarine warfare



WEAPON-FIRING SHIP

Underwater trajectory

WEAPON

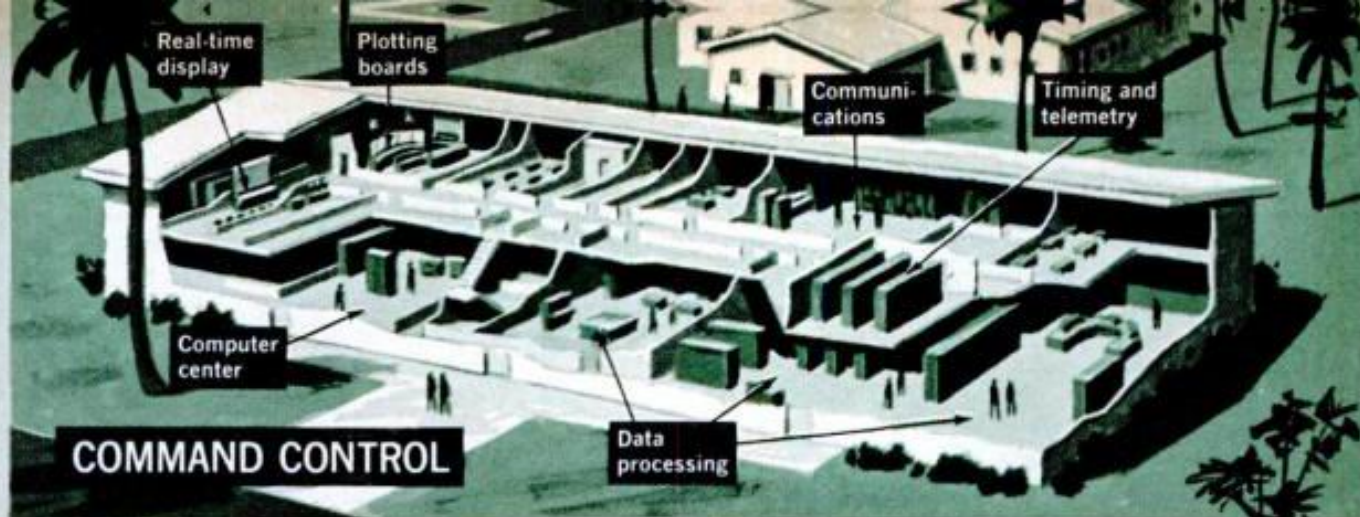
WEST PALM BEACH

177 miles

Tongue of the Ocean (TOTO)

AUTEC RANGE

Red Bull



COMMAND CONTROL

What's happening on Weapons Range is displayed and recorded in Command Control building.

MICROWAVE RADIO CHANNELS

TO COMMAND CONTROL

WEAPON-
RETRIEVING
CRAFT

New anti-sub weapons, minus warheads, get tryout on AUTEK's Weapons Range, where natural submarine canyon offers ideal course. In picture, an air-and-underwater ASROC missile pursues target sub, and hydrophones track them both.

HYDROPHONE
ARRAYS

By WILLIAM HARTLEY
ILLUSTRATION BY RAY PIOCH

Chased by the latest in anti-sub missiles, a submarine races along an underwater course. Listening devices called hydrophones track pursuer and pursued—and tell observers how well the weapon fulfills its mission.

That action-packed drama is constantly being enacted at AUTEK, the U.S. Navy's Atlantic Undersea Test and Evalu-

Continued

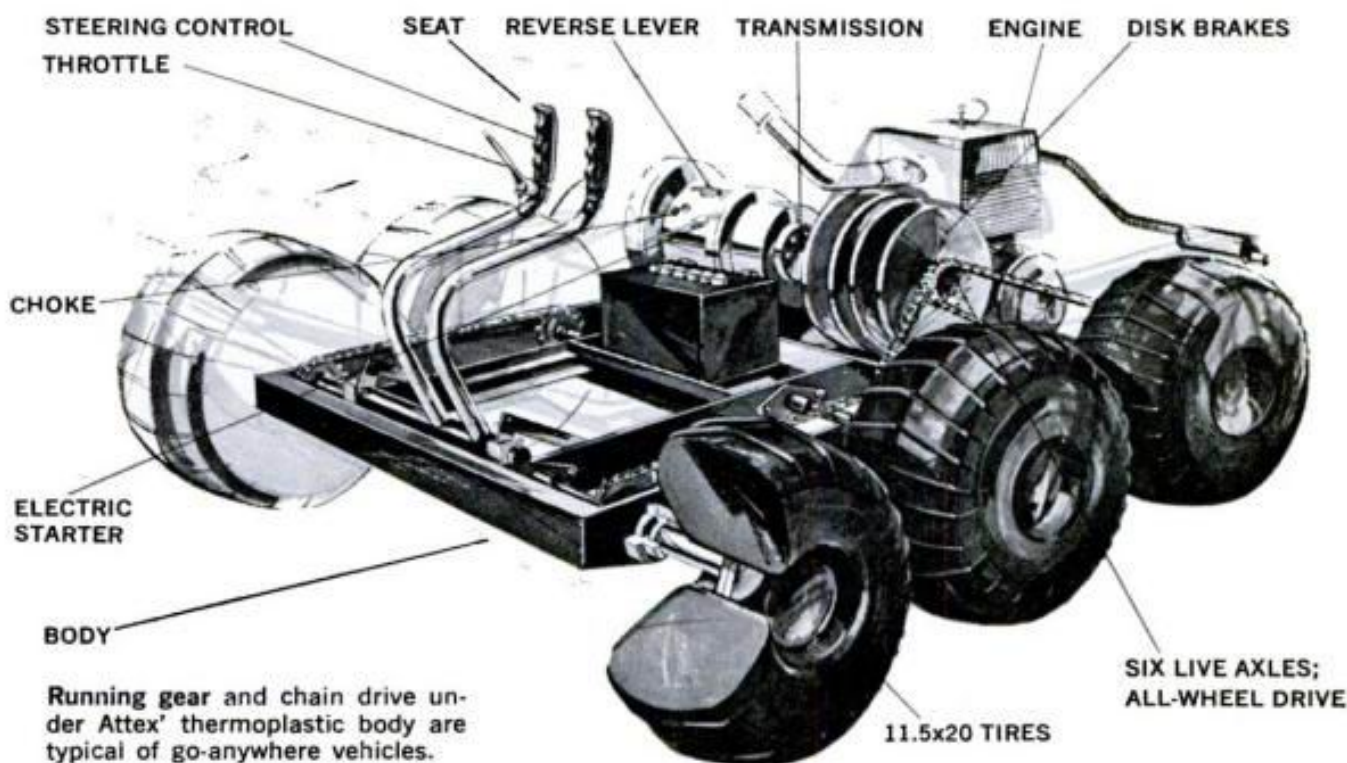
TARGET
SUBMARINE



Attex afloat does four m.p.h. on own engine; optional outboard can better this.



Rolling over gal's legs, off-road sportster leaves her unharmed. Ground pressure exerted is only one pound p.s.i.



Snowmobile has no skis

This Swedish snow vehicle, the Larven, can carry a man on skis and tow another skier. Powered by an eight-hp. two-cycle engine that drives a track through an automatic transmission, it will let you make tracks at speeds up to 40 m.p.h. The 150-pound rig is used by skiers to climb slopes. Two will fit inside a station wagon.



Will our new ABMs really protect us from enemy attack? Here's one shocking view from a well-known expert

McNamara's Missile Defense

A Multibillion-Dollar Fiasco?

By PHILIP WYLIE ILLUSTRATIONS BY RAY PIOCH

Will McNamara's "thin shield" of antiballistic missiles improve my chances to survive a nuclear war?

That's the vital question for most Americans as the present antiballistic-missile debate grows hotter. And it's the key question, too.

So POPULAR SCIENCE has asked me to try to answer it. With their many pounds of basic material, with my own reading, and from my experience as a former consultant in matters of nuclear defense, offense, weapons, and civil defense, I've done my homework. And this is my opinion.

First, even though most PS readers won't need the data, let's define our "thin shield" as currently planned. Basically, it consists of two types of solid-propellant rockets carrying nuclear warheads and highly advanced ground radar equipment. The rockets are the Spartan, a long-range, beefed-up version of the Nike Zeus; and the Sprint, a short-range, close-in defender designed to neutralize or destroy enemy warheads that escape the Spartan. The two radar systems used are called PAR, for Perimeter Acquisition Radar, and MSR for Missile Site Radar.

When an incoming warhead is pinpointed by PAR, Spartans are launched and MSR takes over. With a range given by Pentagon sources as "in excess of several hundred miles" (and some authorities say 400 miles), a relatively thin deployment of Spartans at 15 to 20 sites across the country could—in theory—defend outer space against in-

Continued

New Spartan ABM (left) uses Nike Zeus technology, but has four times range of 100-mile Zeus. It uses three solid stages, is 54.5 feet long, 3.6 feet in diameter. Now in development, it will be tested at Kwajalein Island during next two years. Sprint (right) for close-in defense, is available now [see "The Truth About Our Missile Defense," PS, Oct. '65].





Long-distance PAR radar (1) spots enemy ICBMs on launch. MSR radar (2) takes over, launching Spartans (3, 5). On radar-directed rendezvous with enemy warheads up to 400 miles away in outer space

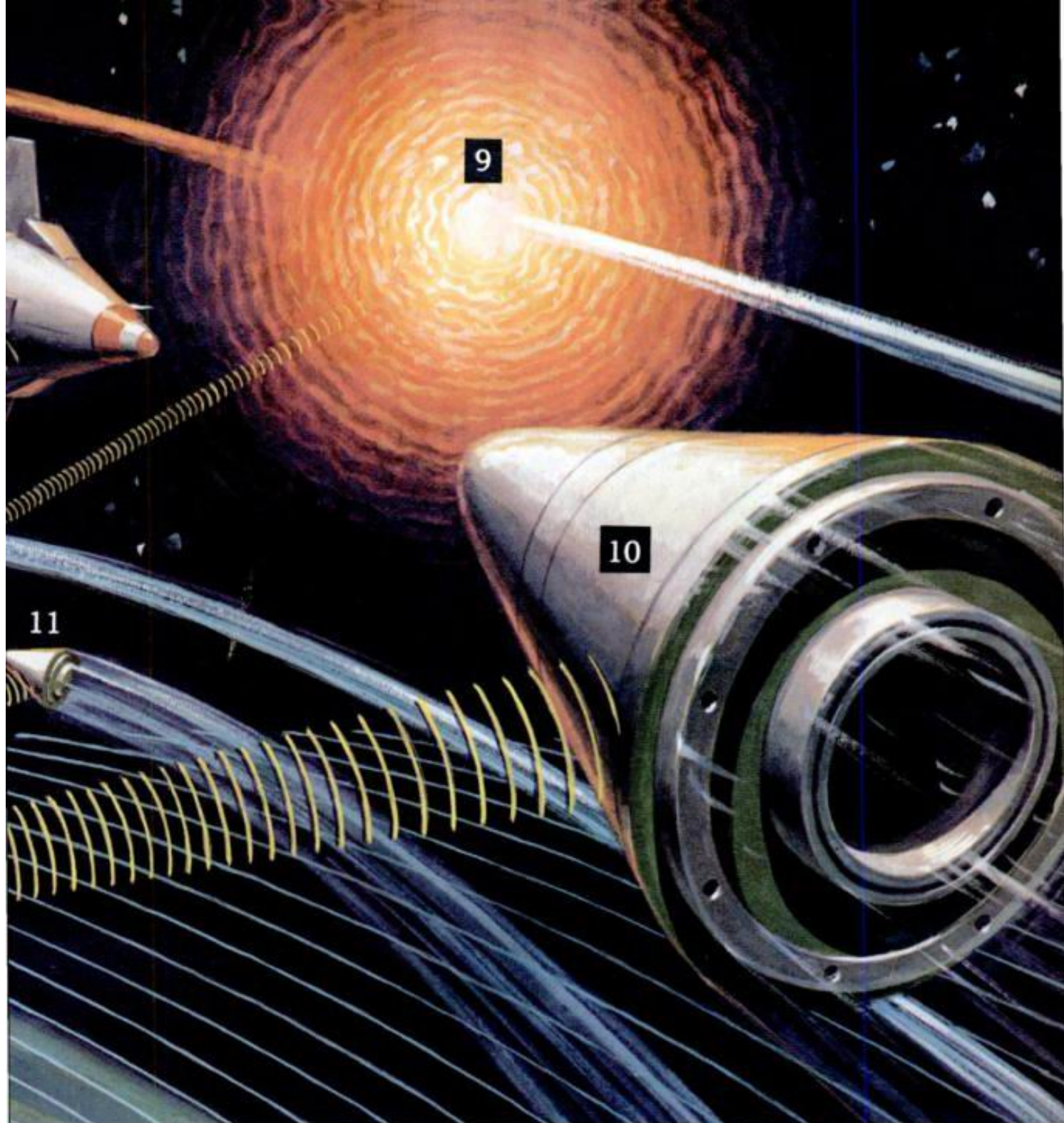
(8, 10), commands from ground detonate ABM, creating sphere of intense radiation at least several miles in diameter to neutralize incoming H-bombs (9). Area defense is feasible because of the high

truders over any part of the United States.

The Spartans will be area weapons. That is, they are intended to neutralize or destroy all enemy warheads within a sphere in excess of several miles in diameter (some authorities say six or seven miles) in outer space. They would have this capability *only* in outer space, for they will depend on the radiation (primarily X rays) and heat emitted by their thermo-

nuclear warheads (which would be quickly absorbed in the atmosphere) to kill complex enemy electronic guidance systems, perhaps neutralize fissionable materials, and melt vital components.

The Sprint, which will operate within the atmosphere, has a much shorter range (15 to 20 miles or 20 to 30 miles according to various sources) and a much smaller kill area, perhaps on the order of hundreds



radiation output of an H-bomb exploding in outer space (at least two-thirds of its energy becomes X rays), and because there is no atmosphere to absorb the radiation. It would destroy enemy guid-

ance systems, possibly neutralize fissionable material, and fuse other components. Sprint missiles (4, 6) neutralize within atmosphere warheads escaping Spartan barrage (7, 11). Its kill area is limited.

of yards. It is a last-ditch weapon, one that could, hopefully, neutralize warheads that have escaped the Spartans.

This nation has achieved at least one difficult feat in constructing a practical antiballistic missile or ABM. ICBMs launched from California have been intercepted by ABMs launched from Kwajalein in the Pacific, thousands of miles away.

Island radar picked up the ICBMs after

launch. Computers plotted their trajectories. Other computers furnished settings for the controls of the island rockets. At the correct split second these rose and came within destruct range of their targets. Of course, neither weapon carried a nuclear warhead and the exercise involved one ICBM at a time. But, as we have seen, more sophisticated systems have evolved

Continued

This wacky motor road climbs the inside of a hill to get to the top

Corkscrew Tunnel Gives Driving New Twist

Around and around you drive through a circling tunnel—and come out atop a 500-foot-high hill. In this novel way motorists now reach a lofty beauty point, accessible only on foot before, near Drammen, Norway.

More than a mile long, the newly completed tunnel starts with a straight 800-foot bore into the heart of Bragernes Hill. Then it twists upward in six circles of 230-foot diameter. With each complete turn it rises 73 feet, giving a uniform 10-percent grade for an easy drive to a restaurant and lookout point at the top. The 30-foot-wide tunnel is large enough for two buses to pass in comfort.

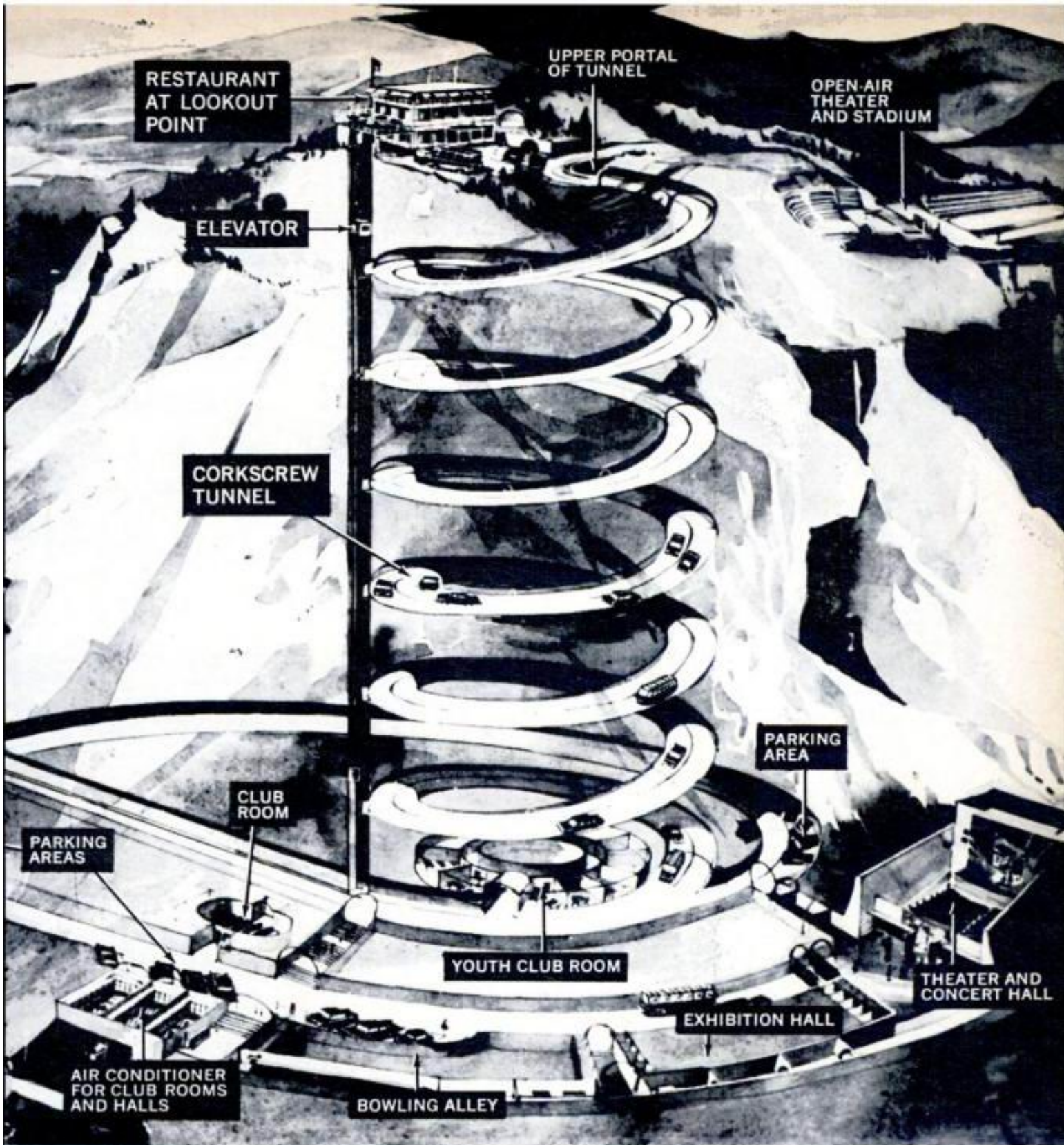
Putting the road inside the hill wasn't as wacky as it looks. When rock quarrying threatened to disfigure the face of the hill, engineers hatched the plan of tunneling for the rock, and creating a tourist attraction, too. Thus the Drammen Spiral was born. Its eight years of construction yielded a bountiful supply of crushed stone for road building. During this time, a vertical elevator shaft for pedestrians served for forced ventilation. Today, quarrying still goes on, to excavate halls and other facilities that will make the site a recreation center.—*David Scott.*



Inside a hill, new tunnel circles to the top



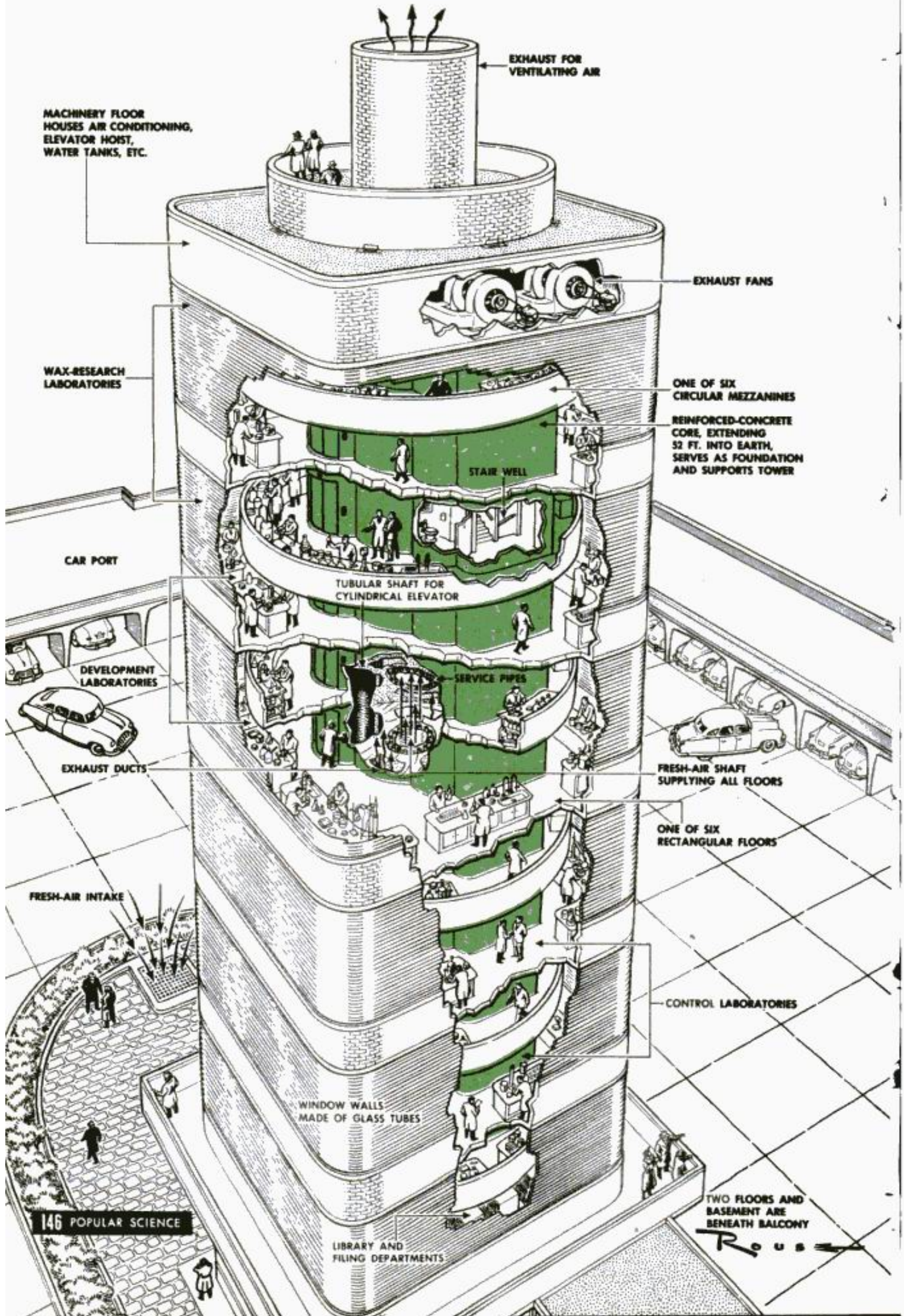
Interior view of winding tunnel, more than a mile long, shows its generous size—30 feet wide and 15 feet high. Roadway climbs to top of hill at easy grade of one foot in 10. Natural convection currents keep air fresh without need of artificial ventilation, and 40-degree temperature of mass of rock prevents icing.



pictured in cutaway view, which includes present elevator and coming additions to facilities

At upper end of corkscrew tunnel are restaurant and lookout point giving this scenic panorama of surrounding countryside. Site overlooking Drammen, Norway, is to be made a recreation center with coming addition of stadium and open-air theater on hilltop, and other facilities at base of 500-foot-high hill.





MACHINERY FLOOR
HOUSES AIR CONDITIONING,
ELEVATOR HOIST,
WATER TANKS, ETC.

EXHAUST FOR
VENTILATING AIR

EXHAUST FANS

WAX-RESEARCH
LABORATORIES

ONE OF SIX
CIRCULAR MEZZANINES

REINFORCED-CONCRETE
CORE, EXTENDING
32 FT. INTO EARTH,
SERVES AS FOUNDATION
AND SUPPORTS TOWER

STAIR WELL

CAR PORT

TUBULAR SHAFT FOR
CYLINDRICAL ELEVATOR

DEVELOPMENT
LABORATORIES

SERVICE PIPES

FRESH-AIR SHAFT
SUPPLYING ALL FLOORS

ONE OF SIX
RECTANGULAR FLOORS

CONTROL LABORATORIES

FRESH-AIR INTAKE

WINDOW WALLS
MADE OF GLASS TUBES

LIBRARY AND
FILING DEPARTMENTS

TWO FLOORS AND
BASEMENT ARE
BENEATH BALCONY

Research Laboratory Built Like a Tree

Drawings by Stewart Rouse

WHENEVER Frank Lloyd Wright designs a building, you can be sure it'll be different. Usually it is also good looking and functional. This, one of his newest, is no exception.

A 15-story research laboratory for S. C. Johnson & Son, the wax-making firm, it looks something like an oversized chimney, but actually is more closely related to a tree. The foundation and load-bearing frame is a reinforced-concrete core, like a tree trunk, that extends 52 feet down into the ground and rises 156 feet into the air. The working floors are supported by cantilevers from the core, like branches from a tree trunk. The outside walls are "curtain" walls—they don't support the building, but merely keep bad weather out. They are mainly two-story-high windows separated by bands of brick. The windows, made of glass tubing, are unbroken by sash.

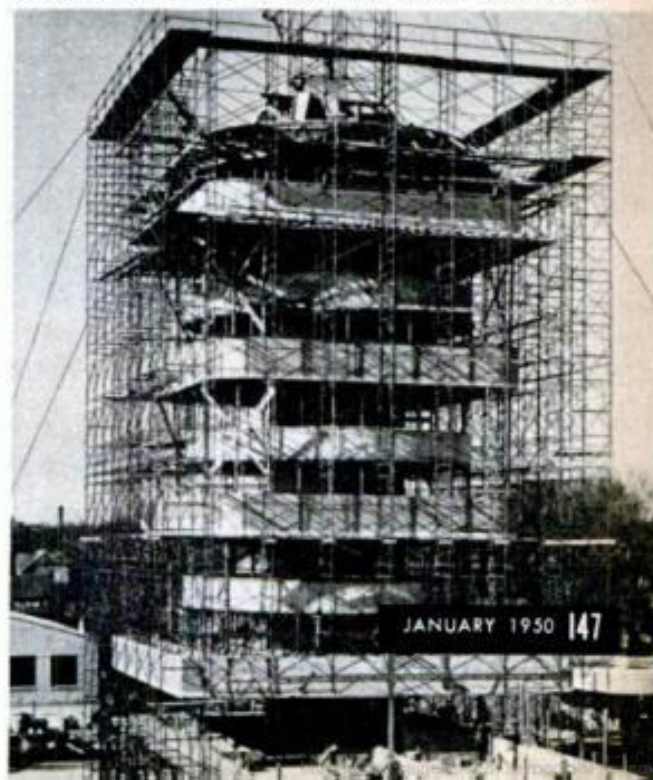
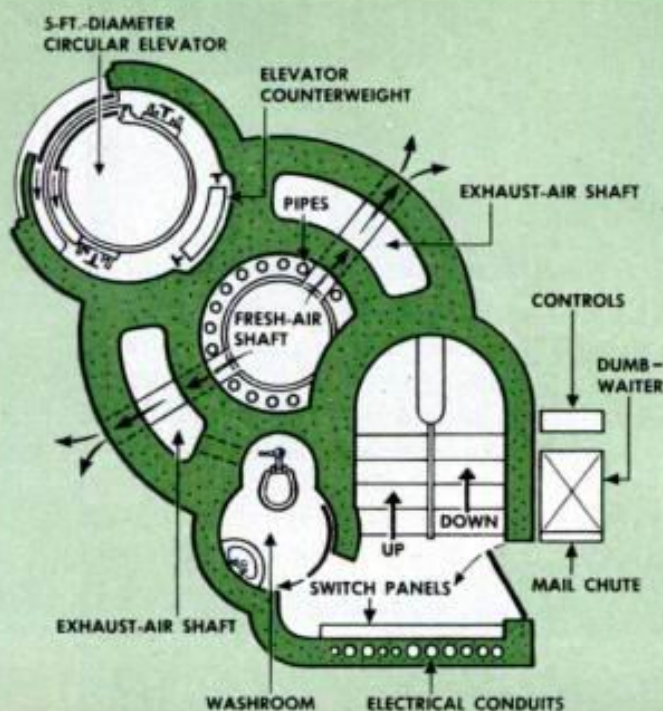
Research tree's trunk, shown in plan view below and in perspective in drawing on facing page (solid-colored section), will contain all pipes, wires, shafts, and other services for building.

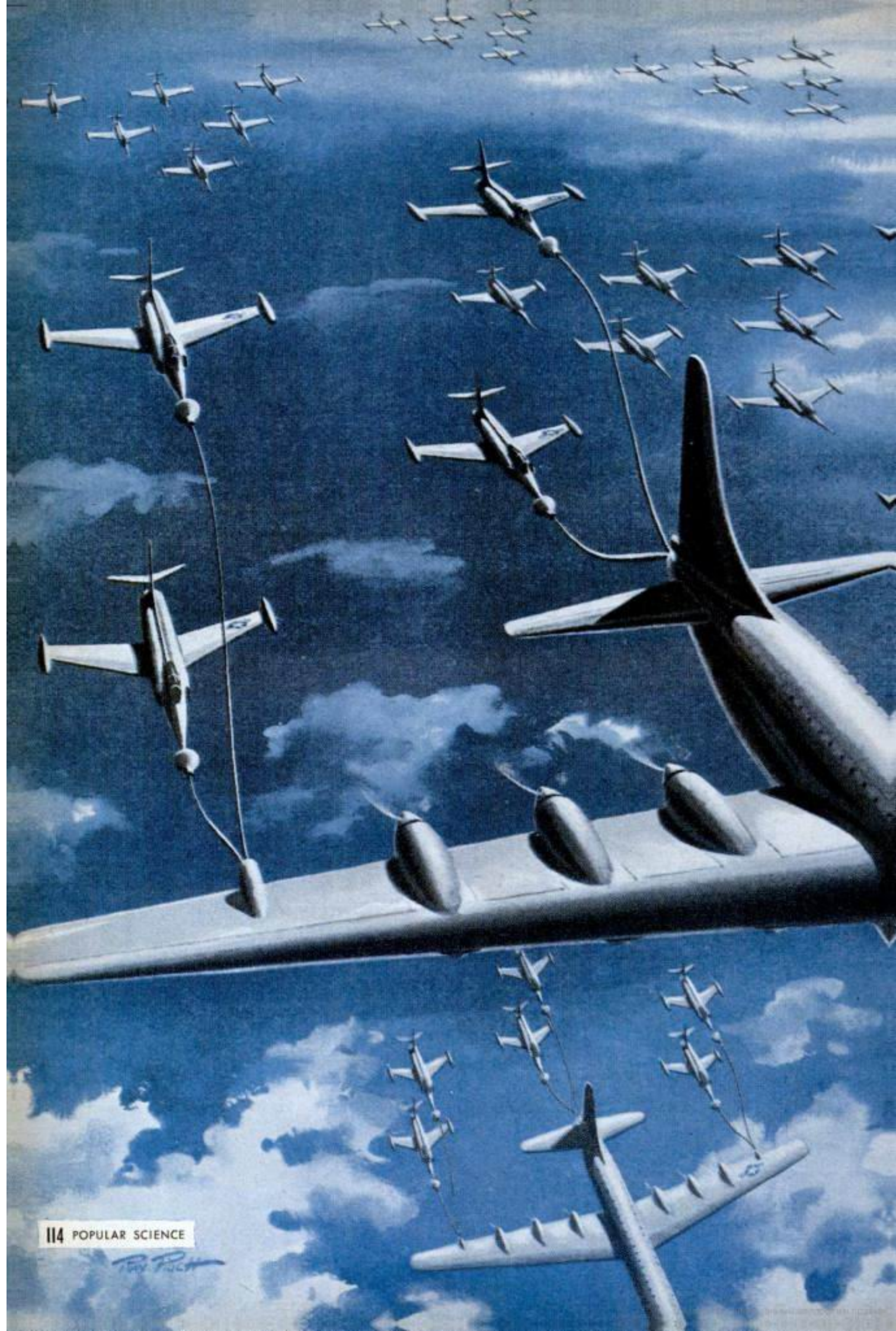
As in a tree, all supply services are centralized in the core. A large shaft in the center furnishes fresh, conditioned air. Two other shafts on either side take care of exhaust air. Piping for the various laboratory services surround the fresh-air shaft, while lighting and power conduits are enclosed in an outer wall of the core. The core also has a small circular shaft for a cylindrical elevator that can travel all 15 stories in 20 seconds. The elevator even has circular doors and curved counterweights. Opposite this is the stair well.

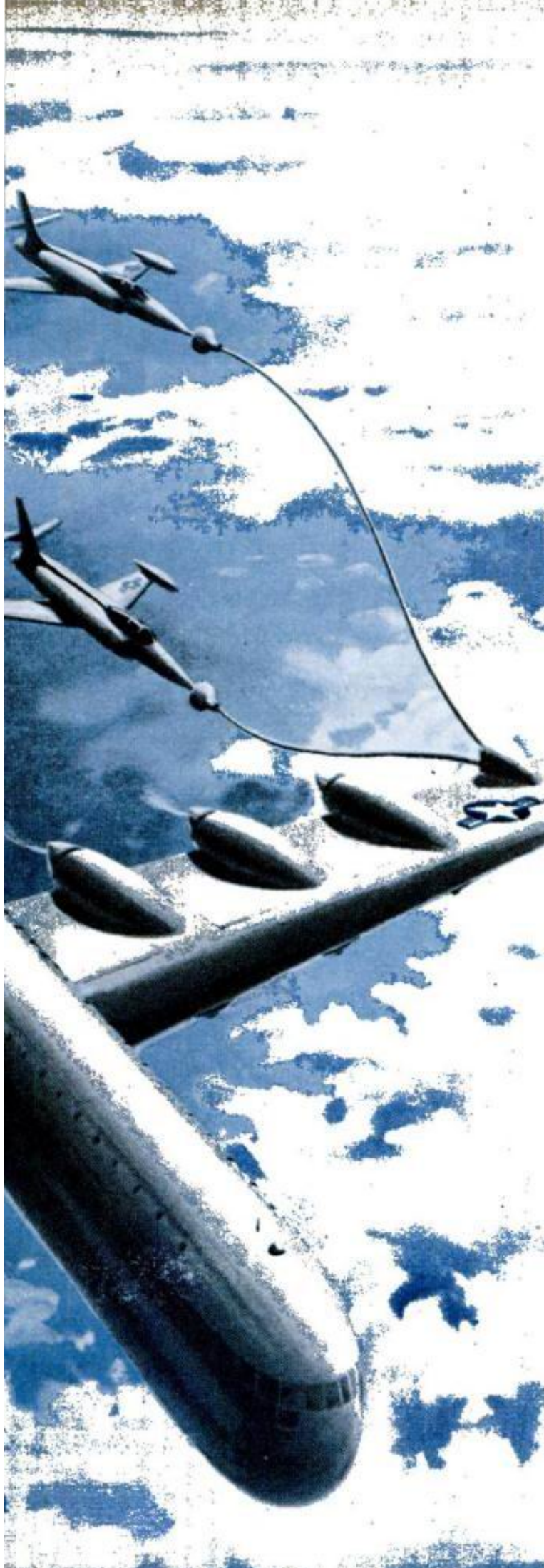
There are two types of working floors: a circular mezzanine balcony overlooks a rectangular, full-width floor. Both types are unobstructed, open to all the light from the huge window walls.

The research tree rises from an open court near the company's administration building, which was also planned by Wright. **END**

Arrangement of circular mezzanine and rectangular floors that share a two-story-high window can be seen in photo (below) made during construction of S. C. Johnson & Son's laboratory.







Air Tankers Fuel Jets for Long Flights

Speedy new system for refueling on the wing opens way for revised air strategy and faster airline trips.

By Devon Francis

Drawings by Ray Pioch

IT LEAKED out last month that the U. S. Air Force had three Republic Thunderjet fighter planes equipped to be completely refueled in mid-air in 90 seconds each—and the way was opened for a fundamental revision in the nation's air defense strategy.

The perfection of a quick in-flight refueling system also promised seven-hour transatlantic schedules by jet-propelled passenger transports, perhaps within a year.

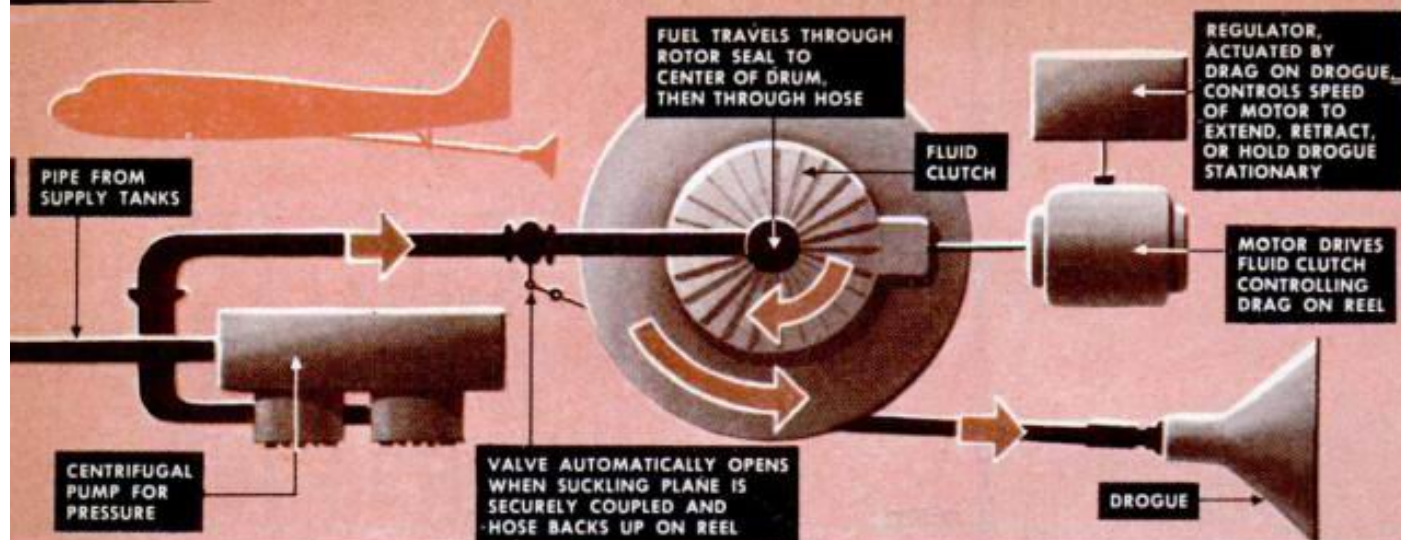
It forecast the probability of ultimate five-hour passenger flights coast-to-coast in jet-propelled aircraft.

It offered the U. S. Navy new versatility and striking power for its carrier fleet.

It solved, finally, the most serious drawback of the airplane—its inability to carry a great load a long distance nonstop.

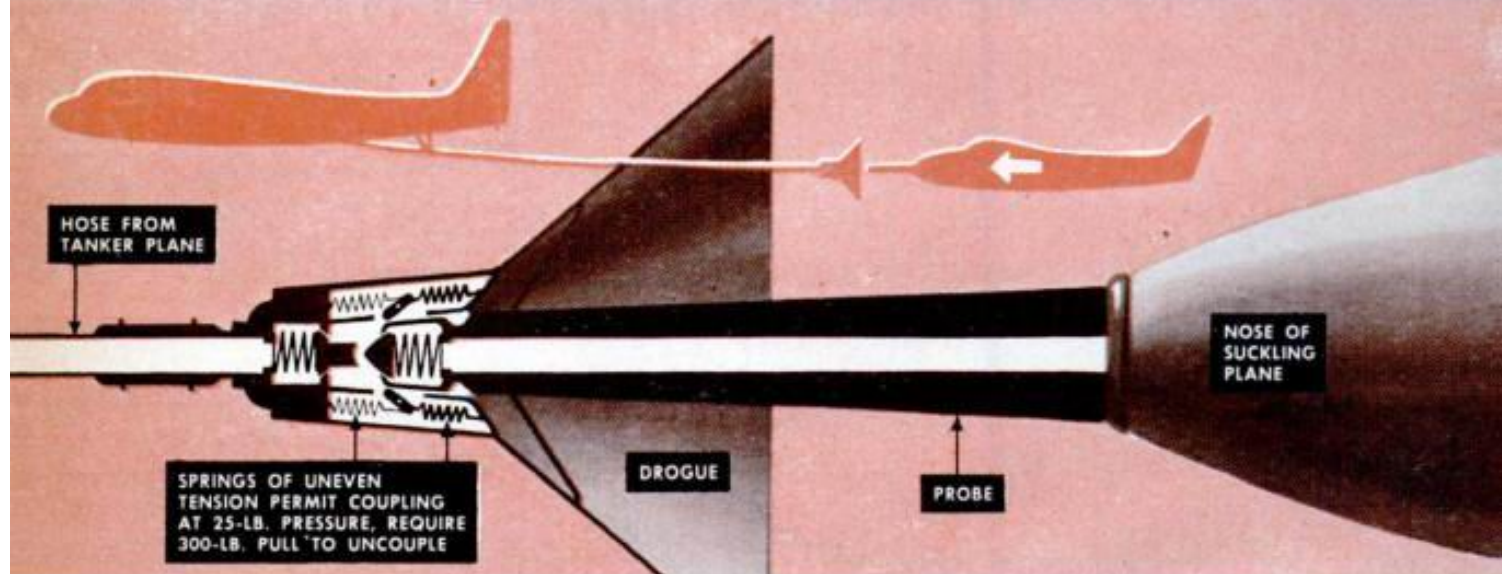
The fast, automatic transfer of fuel from tanker planes to military and commercial aircraft has been 15 years in the making. Now it is a reality. In-flight refueling will become a commonplace for both bombers and fighters in the next few months. What this means in terms of air defense can be reduced to simple mathematics.

A bomber propelled by reciprocating engines and refueled once in mid-air en route to its target can carry *three times* 



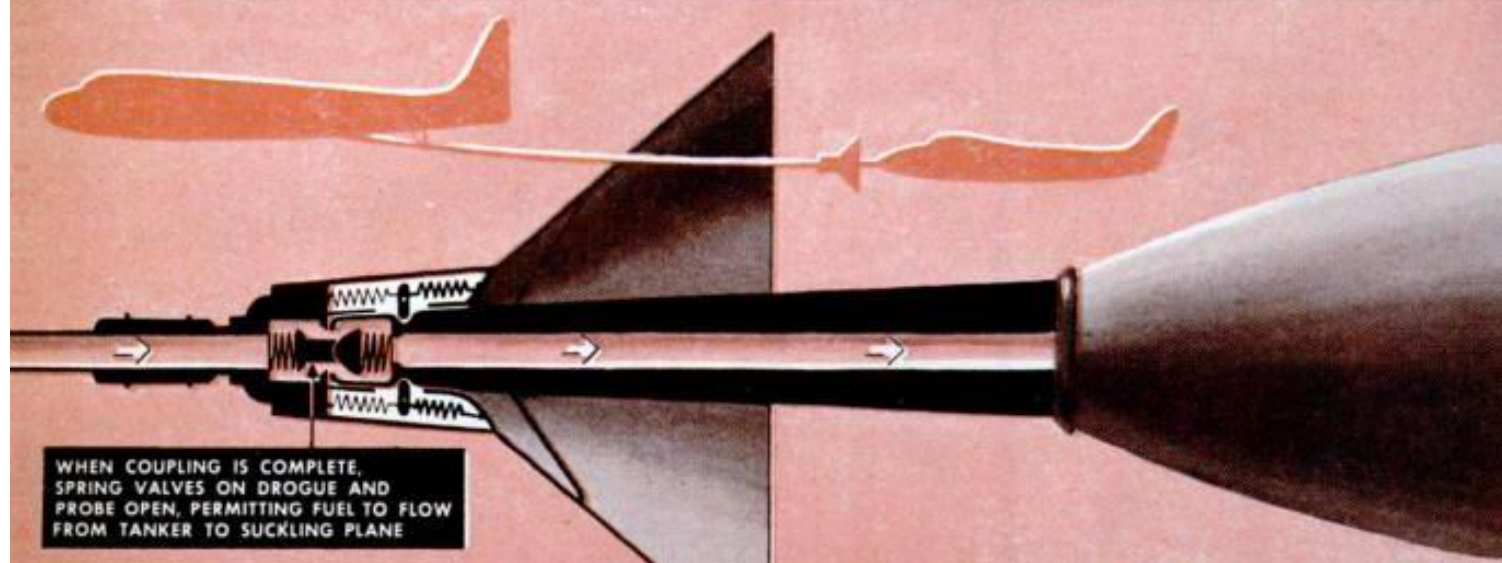
One of two chief components in flight refueling is 70-foot flexible-metal hose. In military

operations, tanker carries it; in commercial refueling, the air liner will unreel it to the tanker.



Three toggles in drogue clamp over annular groove in probe. Joint is sealed by synthetic-rub-

ber ring. Plane carrying probe eases forward, and pressure flashes a green light in tanker cockpit.



Tanker crew then switches on fuel pumps. Play in drum rotation allowed by fluid clutch enables

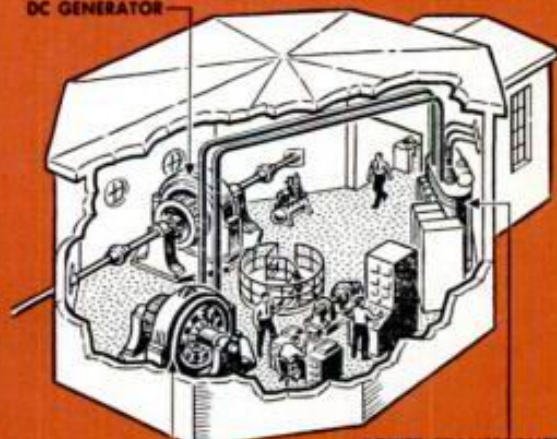
two planes to maintain contact if momentary speed differences are not more than 25 m.p.h.

Power Plant on Stilts

This drawing shows what may someday be the answer to engineers' dreams of large-scale electric power from the wind. The design, made by Percy H. Thomas for the Federal Power Commission, envisions a 475-ft. tower topped by two giant rotors, each 200 ft. in diameter. These are mounted on a large turntable that also houses the generating equipment (small sketch).

Plans are based on experiments near Rutland, Vt. (PS, July '41, p. 115). Batteries of these two-bladed, wind-powered generators, each with a 7,500-kw. capacity, could be used, says Mr. Thomas, to supplement conventional hydroelectric or coal systems. The U.S. Bureau of Reclamation likes the idea for dry Western areas short on water power.

DC GENERATOR



SYNCHRONOUS CONVERTER CHANGES DC TO AC

POWER TRANSFORMER STEPS UP VOLTAGE FOR TRANSMISSION

Is Russia Building These Speedsters?

By Chalmers ("Slick") Goodlin

AT THE end of World War II, the Russians rounded up some 80 percent of the Nazi aircraft industry and moved its brains, experience and factories behind the Iron Curtain. A juicy prize, for it is well known that the Germans had designs for jets and rockets far in advance of any U. S. development at the time.

"Has the Soviet exploited this advantage?" I asked a private source in Europe that has proved reliable in the past. In reply, I received these three drawings, published here for the first time, of planes designed for *sustained* supersonic flight.



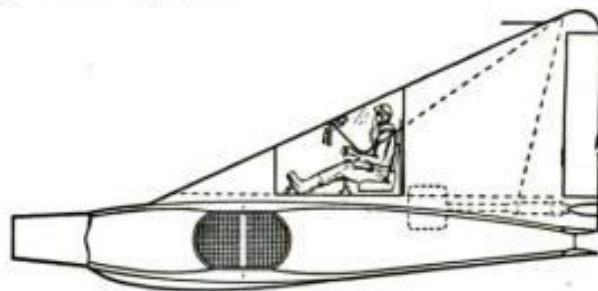
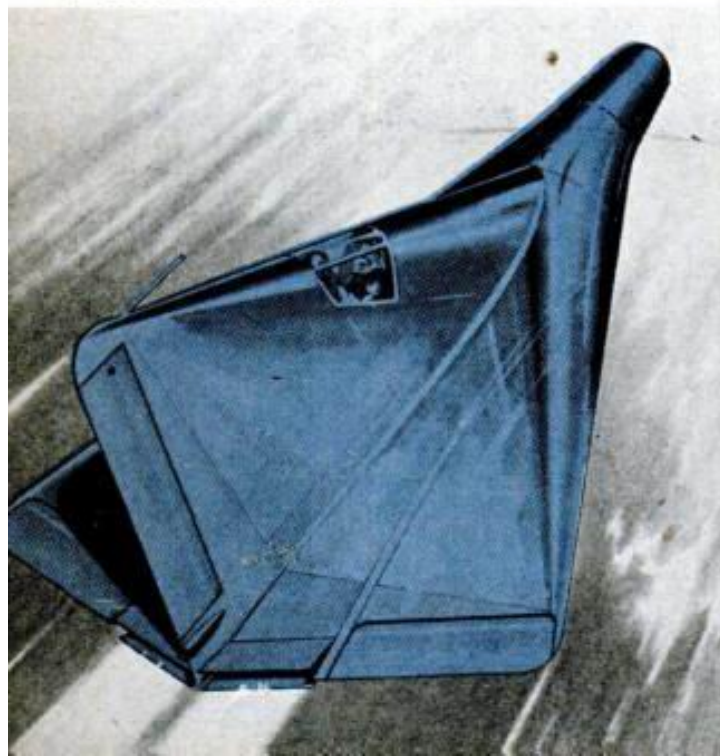
The Russians may have added a T-tail to the Heinkel P-1080. In the design shown above, the twin ramjet engines, about 16 feet long and three feet in diameter at the combustion chamber, are bigger than the fuselage. And the entire fuselage, behind the nose-tip cockpit, is prob-

A **flying wedge** like one below is reported to be on the Russian drawing boards. As radical as its design is the ramjet power plant—reportedly able to push the wedge to double the speed of sound. Indications are that it can burn powdered *coal*—a steal from the oil-starved Luft-



ably a huge fuel tank. Although no rocket-assisted take-off device is evident, some RATO scheme must be provided for ramjets. Retractable landing skids may be another feature. Progress on this design is not known, but considerable work is reported.

waffe. The cockpit shown is a 65-degree-sweep fin. Wing has a 60-degree sweep, with a split jet exhaust in the tail. It is believed the Soviet has a 6,600-pound-thrust rocket that can get the plane to the speed at which its ramjet engine will operate.





Engines in the tail are a futuristic feature reported in this possible Soviet development of Kurt Tank's Ta-283 Focke-Wulf design. From information available to him, the artist has drawn details of tail-mounted ramjets with a rocket engine in the fuselage. With a wing sweep of 45 degrees, this design is rumored to have a span of about 26 feet and length of almost 39 feet. Fuel tanks are just forward and aft of cockpit, which fairs into tail fin. Rocket engine could be used for take-off, for acceleration to ramjet speed and for bursts of combat speed.

Giant Doughnut Proposed as Space Station

A rocket scientist presents a design for a man-made, man-carrying satellite to circle the earth 1,075 miles up.

INWARD is "up" and outward is "down" in the extraordinary structure pictured here. Dwellers in it would walk on its outermost wall, their heads toward its hub.

The drawing gives a scientific preview of an inhabitable "space platform" floating in the sky at a 1,075-mile altitude and circling the earth as a satellite.

An "artificial moon" such as this could serve as a military base, observatory and rocket-ship refueling station. Its possibilities have been reported under study by the Department of Defense. What it may look like is now revealed by a former German V-2 rocket expert, Dr. Wernher von Braun, of the Ordnance Research and Development Sub-Office, Fort Bliss, Texas. In a book just published by the University of Illinois, *Space Medicine*, he presents his conception of a feasible design.

Will Make Own "Gravity"

His proposed space platform, of 200-foot diameter, resembles a giant doughnut. It rotates slowly on its axis. As if in a submarine, its crew live and work inside its air-conditioned and pressurized rim.

Gravity will be absent. But centrifugal force from the rim's rotation gives occupants a foothold and enables them to walk along the wall. This artificial gravity also averts possible ill effects of prolonged weightlessness upon the human system.

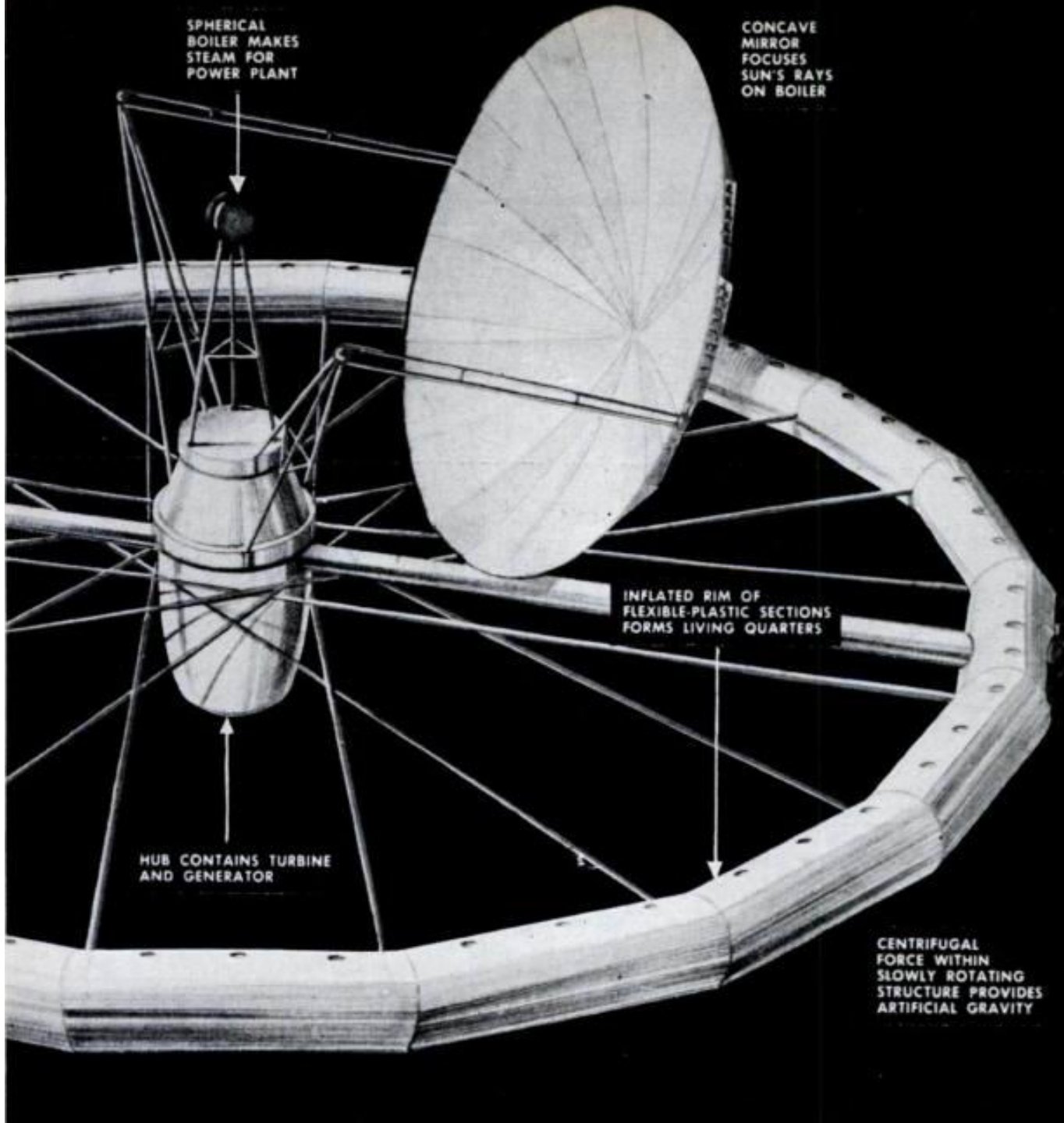
A silvery concave mirror focuses solar rays upon a boiler, making steam to run a turbine and generator for electric power.



By rocket ship, Dr. von Braun proposes, the platform's parts will be carried to its orbit for assembly there. Ten to 20 collapsible sections of flexible plastic, which can be unloaded through small hatches, will form the bulky rim. Men in pressurized space suits will join them and inflate the ring like a tire. Unloaded at an orbital speed offsetting the earth's pull, men and materials will float in space, as will the assembled platform.

But its inhabitants will not be marooned there. Rocket-ship "ferries" plying between the earth and its new satellite will pick up returning personnel and deliver relief crews, provisions and rocket fuel.

Feasibility of the whole idea, of course,



hangs upon developing rocket ships that can erect and serve the space station. Such a ship, Dr. von Braun has calculated, will be a triple-stage rocket of 30-ton payload, about 200 feet long and 65 feet in maximum diameter. In flight it will launch a second, smaller rocket and this one will in turn launch the third and final rocket carrying passengers and cargo. The third-stage rocket will be winged for a gliding landing on its return to earth.

Satellite Could Drop Bombs

Incentives to erect a space platform are urgent, Dr. von Braun points out. An observatory free of atmospheric disturbances, it could have telescopes powerful enough

to see people on earth. It would offer weather forecasters and astronomers an ideal view of the earth's cloud formations and the stars. As a way station, it would speed the day of interplanetary travel.

More immediately vital, it would make a non-interceptible bomb carrier, swooping around the earth in two hours at a height beyond reach of present defense weapons. It could launch rocket missiles and guide them accurately by remote control and radar to any spot on earth.

"It appears to me," Dr. von Braun declares, "that in the atomic age the nation which first owns such a bomb-dropping space station might be in a position virtually to control the earth."

END

The World in 3-D

Scientists, hikers, and generals will all benefit from a new three-dimensional map of the world. **By Philip Chien**

WHEN THE SPACE SHUTTLE Endeavour returned to Earth in February, it brought back the most comprehensive three-dimensional map of our planet to date—covering 119 million square kilometers. Some areas of the world, including most of the United States, have already been mapped in finer detail. But in places like Brazil's Amazon basin, the new map will reveal slopes and valleys that couldn't be seen on earlier maps.

For the military, that will make it easier for missiles to fly below enemy radar. Nonmilitary applications include geological research, planning sites for cellphone towers, and better maps for hikers. "Now we have a map of the world at 30 meters resolution," says project scientist Michael Kobrick, "not just an image of the world, not just a road map, but a 3-D map. It's truly an astounding achievement." ♦

Flying Mapmaker

FUNDED BY THE National Imaging and Mapping Agency, the shuttle's radar system mapped the world at a resolution of 30 meters. Versions sold to the public will probably be of lower resolution.

Outboard antenna

Expandable boom

Payload bay

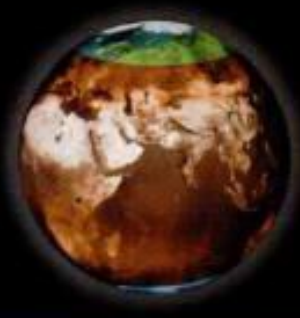
1 To do its mapping work, the shuttle points its payload bay at Earth, with its tail leading the way as it orbits 145 miles above the surface. Astronauts periodically fire jet thrusters to keep the inboard and outboard antennas aligned.

2 The outboard antenna is mounted on an expandable boom that stretches 200 feet over the shuttle's side. The boom is the longest rigid object ever deployed in space, twice the length of previous experimental booms.

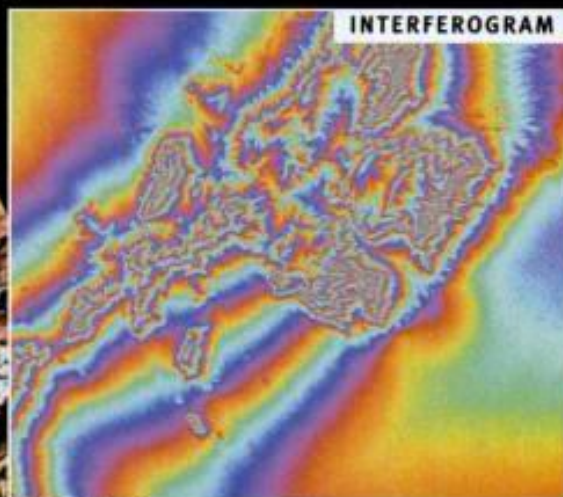
C-band radar

X-band radar

3 The C-band radar is the primary radar system on the mission. A secondary X-band radar, supplied by the German and Italian space agencies, covers smaller swaths of Earth's surface but at higher resolution.



The shuttle mapped 80 percent of Earth, from a latitude of 60 degrees north to 55 degrees south, home to 95 percent of the planet's people. Radar can penetrate clouds and darkness for full coverage.



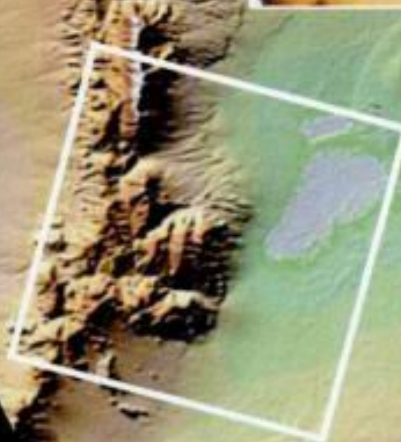
INTERFEROGRAM

4 Antennas on the shuttle and boom bounce radar off the surface simultaneously, creating interference patterns like the ripples produced by two pebbles dropped in a pond. By analyzing these interference patterns the mapping system can acquire topographic data.



DIGITAL ELEVATION MODEL

5 Topographic data can be merged with other digital data. For example, a satellite image can be "draped" over the elevation data to create a 3-D perspective view with realistic colors. At left is White Sands, New Mexico.



PERSPECTIVE MAP

The radar data fill 326 high-density cassette tapes, the equivalent of 20,600 CD-ROMs. It will take the equivalent of 144 Pentium-class computers running 12 hours a day for 140 days to process the data into a worldwide map.

INFOGRAPHIC DON FOLEY

READY FOR TAKEOFF

THE EUROPEAN Airbus Industrie group has unveiled its long-awaited design for the A3XX jumbo jet. Once Airbus receives 50 firm orders, production will begin. The first test flight is slated for late 2004, with deliveries to begin a year later.

Wide Cabin

The A3XX has an oval cross-section that provides room for two full passenger decks, plus a windowless below-deck area that can be used for cargo or passenger services such as a restaurant, fitness room, or even sleeper cabins.

Broad Wing

Most airport gates can accommodate a wingspan of only 80 meters, so Airbus designed a lightly loaded wing with a broad base, and a cross-section that varies continuously from the wing's root to its tip to distribute lift efficiently.

Quiet Engines

To power the four-engine A3XX, buyers can choose either the Rolls-Royce Trent 900 or the Alliance GP7200, developed by General Electric and Pratt & Whitney. Both have an extra-large set of fan blades to send air into and around the combustion chamber. The cool air mixing with hot air at the back of the engine acts like a muffler, reducing noise.

Hot and cool air mix upon exit

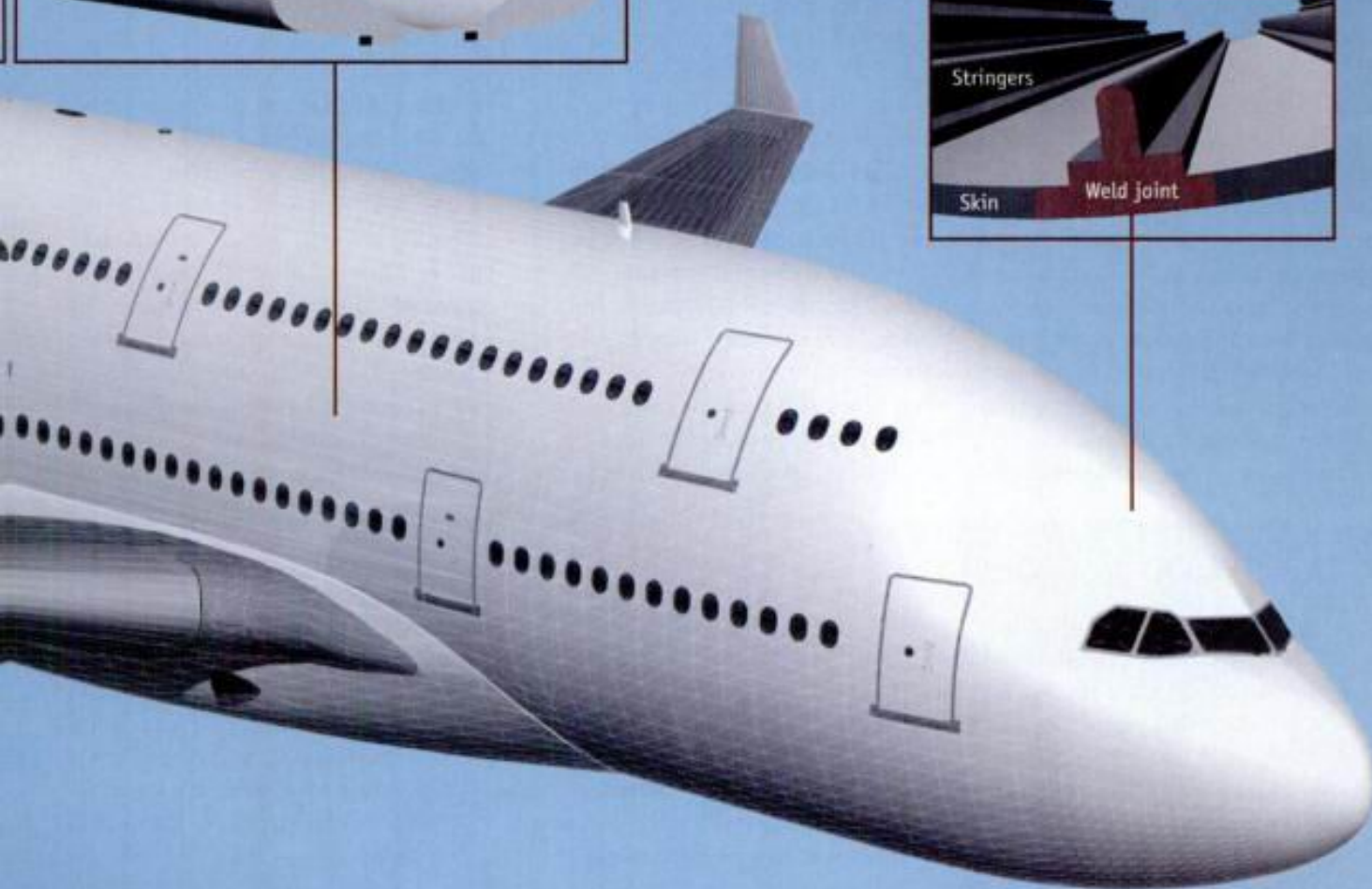
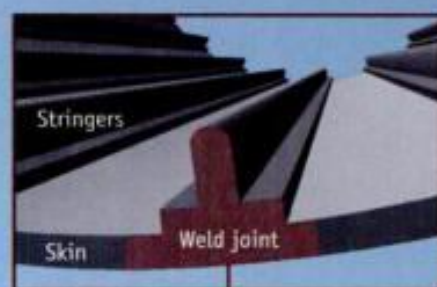
Combustion chamber

Fan blades



Tight Joints

Airplane manufacturers usually attach "stringers," or stiffeners, to body skin panels with thousands of fasteners. For the A3XX, Airbus will substitute a technique called laser welding, which eliminates the need for fasteners and helps prevent corrosion. An aircraft's skin is too thin for conventional welding.



New materials and advanced aerodynamics make it possible to build a two-story "megaplane" that will be the world's largest passenger jet.

Double Decker

By Bill Sweetman

B-3 and Beyond

By Steve Douglass

SUPERCRUISING DELTA-WING

Northrop Grumman has released its technical renderings for a concept vehicle with supercruise capability. They depict a delta-wing craft that could serve as a fast but recallable nuclear weapons delivery system.

HYPERSONIC SPEED

Northrop Grumman has also unveiled its concept for a hypersonic waverider that could reach speeds of Mach 5 and above. The forebody of this aircraft acts as the engine air intake, and the aft section as the nozzle.

Traveling at speeds of Mach 5 or higher, future bombers could strike targets worldwide within hours.

FUTURE STEALTH

The nation's next heavy bomber, designated the B-3, will likely be a super-stealthy, subsonic follow-on to the B-2. Design drawings are a closely guarded secret, but the aircraft will probably look similar to the B-2.



EVEN BEFORE THE U.S. AIR FORCE finishes building its fleet of 21 B-2 Spirit stealth bombers, aircraft futurists are busy designing the nation's next bomber deep inside a secure vault at Wright-Patterson Air Force Base in Ohio. The B-2 may rule the skies for now, but the bomber that makes it obsolete is already on the drawing board.

It typically takes decades to develop a new weapons system such as a bomber aircraft. That's why the Air Combat Command, which oversees the U.S. long-range bomber force, initiated a Future Strike Aircraft study. The purpose of the FSA study is to have the nation's three prime contractors for airframes—Boeing, Lockheed Martin, and

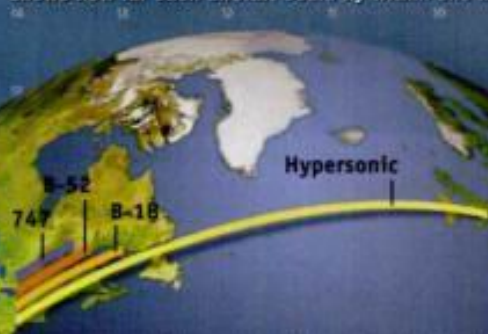
Northrop Grumman—look out to the year 2030 and beyond, developing concepts for future stealth bombers that will meet the anticipated needs of the Air Force. These concepts will guide Congress in planning how to spend the nation's defense dollars in the future.

Final reports from all three companies, including preliminary concept drawings, are due to Wright-

Patterson's Aeronautical Systems Center this month. But one of the competitors, Northrop Grumman, has already unveiled some of its ideas. Designers at the company are covering all bases by submitting concepts for three classes of future heavy bombers: subsonic, supersonic, and hypersonic. The ambitious hypersonic concept proposed by Northrop Grumman would launch weapons at tremendous speeds of Mach 5 and above, equivalent to about one mile per second at sea level.

Why such a high-speed design? Because of advances in anti-stealth technologies, the survivability of future strike aircraft may depend on speed and altitude. "We will be exploring vehicles that would operate in the high subsonic range and others in the supercruise and hypersonic ranges," says Charles Boccadoro, FSA program manager for Air Combat Systems, a research arm of Northrop Grumman

HOW FAST? Mach 1, the speed of sound in dry air at sea level at 32°F, is roughly 750 mph. A 747 jet cruises at three-fourths the speed of sound. A B-52 can go slightly faster, and a B-1B can "dash" at speeds above Mach 1 (although it rarely flies at supersonic speed because of fuel restrictions). To achieve hypersonic speeds, a future bomber would have to fly at Mach 5 or faster. The graphic below shows how far each aircraft could fly within one hour.



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G

GIVE A KID A BEACH AND HE'LL MAKE A SANDcastle; give a man a billion dollars and he'll build the world's tallest building. The urge to engineer big is elemental. "The same aspirations to celebrate and uplift the spirit that drove the Egyptians to build the pyramids are still driving us," says Henry Petroski, a professor of history and civil engineering at Duke University and the author of *To Engineer Is Human*. "The things we're doing differ only in magnitude."

But new technology always ups the magnitude ante. Italy plans to shatter the suspension-bridge record, held by Japan's Akashi Kaikyo Bridge, with a nearly 2-mile span. Taiwan finished the world's tallest building in 2003—and Dubai announced a scheme to surpass it by hundreds of feet.

Building higher and farther requires an enormous, conspicuous marshaling of resources. Extreme engineering projects—real and speculative—thus offer picture-window views into the collective aspirations of societies that would undertake them.

"Does Dubai really need the world's tallest building?" Petroski asks. "These things take great will, and you have to ask, Why are they being built?" One reason: Because they *can* be built by the nations that undertake them. Meanwhile, nations with a long history of superbuilding move on. The United States has skyscrapers and bridges galore. Now it's embarking on the world's most ambitious ecosystem restoration and the world's first long-term nuclear waste storage facility.

Of course, far more superprojects are dreamed of than built. Here, a look at big engineering schemes—some under way, some in the dream stage.

Carl Hoffman is a frequent POPSCI contributor based in Washington, D.C.

● The idea is as wondrous as it is audacious: Get on a train at New York City's Penn Station and hit Paris, London or Brussels just an hour later. "From an engineering point of view there are no serious stumbling blocks," says Ernst Frankel, retired professor of ocean engineering at MIT.

As envisioned by Frankel and Frank Davidson, a former MIT researcher and early member of the first formal English Channel Tunnel study group, sections of neutrally buoyant tunnel submerged 150 to 300 feet beneath the surface of the Atlantic, then anchored to the seafloor—thereby avoiding the high pressures of the deep ocean. Then air would be pumped out, creating a vacuum, and alternating magnetic pulses would propel a magnetically levitated train capable of speeds up to 4,000 mph across the pond in an hour. As Frankel and Davidson say, it's doable. "We lay pipes and cables across the ocean every day," says Frankel. "The Norwegians recently investigated submerged, floating tunnels for crossing their deep fjords, and were only held back by the costs."

Ah, the costs: Estimates range from \$25 million to \$50 million per mile. Another hurdle: safety. But Davidson believes a test case might mitigate concerns. "Maybe a tunnel across Lake Ontario would show how it reacts to dynamic conditions and give us a better understanding of the costs," he muses. "A transatlantic tunnel will be done. We just have to be as interested in it as we are in getting to the Moon."

VACUUM TUBE TRAIN

A 4,000-mph magnetically levitated train could allow you to have lunch in Manhattan and still get to London in time for the theater, despite the 5-hour time difference. It's not impossible: Norway has studied neutrally buoyant tunnels (concluding that they're feasible, though expensive), and Shanghai is running maglev trains to its airport. But supersonic speeds require another critical step: eliminating the air—and therefore air friction—from the train's path. A vacuum would also save the tunnel from the destructive effects of a sonic boom, which, unchecked, could potentially rip the tunnel apart.



Magnetic
levitated

TRANS-ATLANTIC MAGLEV

WHAT: SUBMERGED OCEANIC TUNNEL AND SUPERSONIC TRAIN

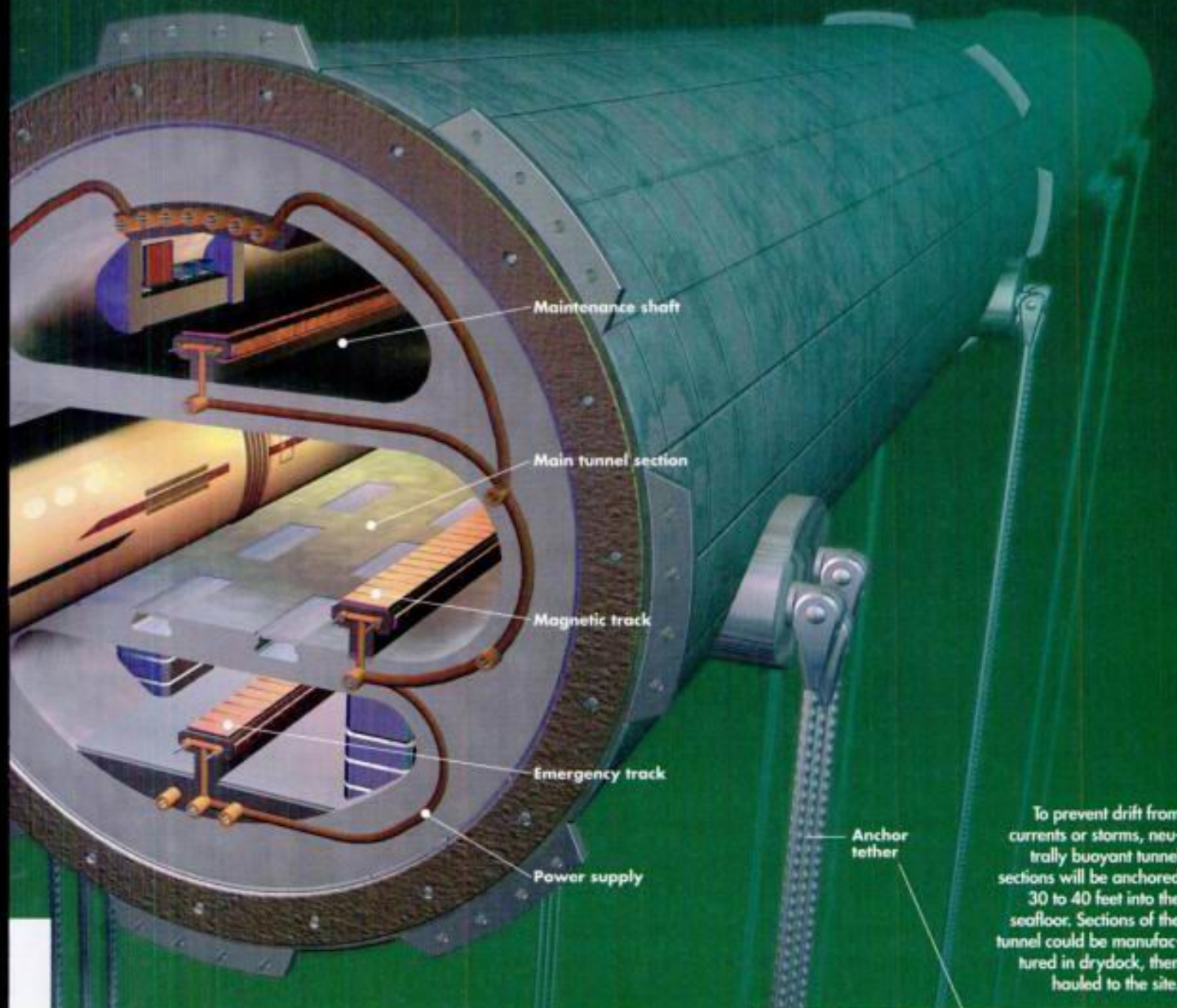
WHERE: NEW YORK – LONDON

COST: \$88 BILLION – \$175 BILLION

CRUX: Neutrally buoyant vacuum tunnel submerged 150 to 300 feet beneath the Atlantic's surface and anchored to the seafloor, through which zips a magnetically levitated train at up to 4,000 mph.



One proposed route for the transatlantic maglev train passes through northeastern Canada before barreling toward the British Isles and continental Europe, briefly kissing terra firma on Greenland and Iceland. Because above-ground sections would be cheaper to build than their underwater counterparts, such a route would be more economical than a direct shot through the Atlantic.



To prevent drift from currents or storms, neutrally buoyant tunnel sections will be anchored 30 to 40 feet into the seafloor. Sections of the tunnel could be manufactured in drydock, then hauled to the site.

Anchor tether

Levitating magnets

Propulsive magnets

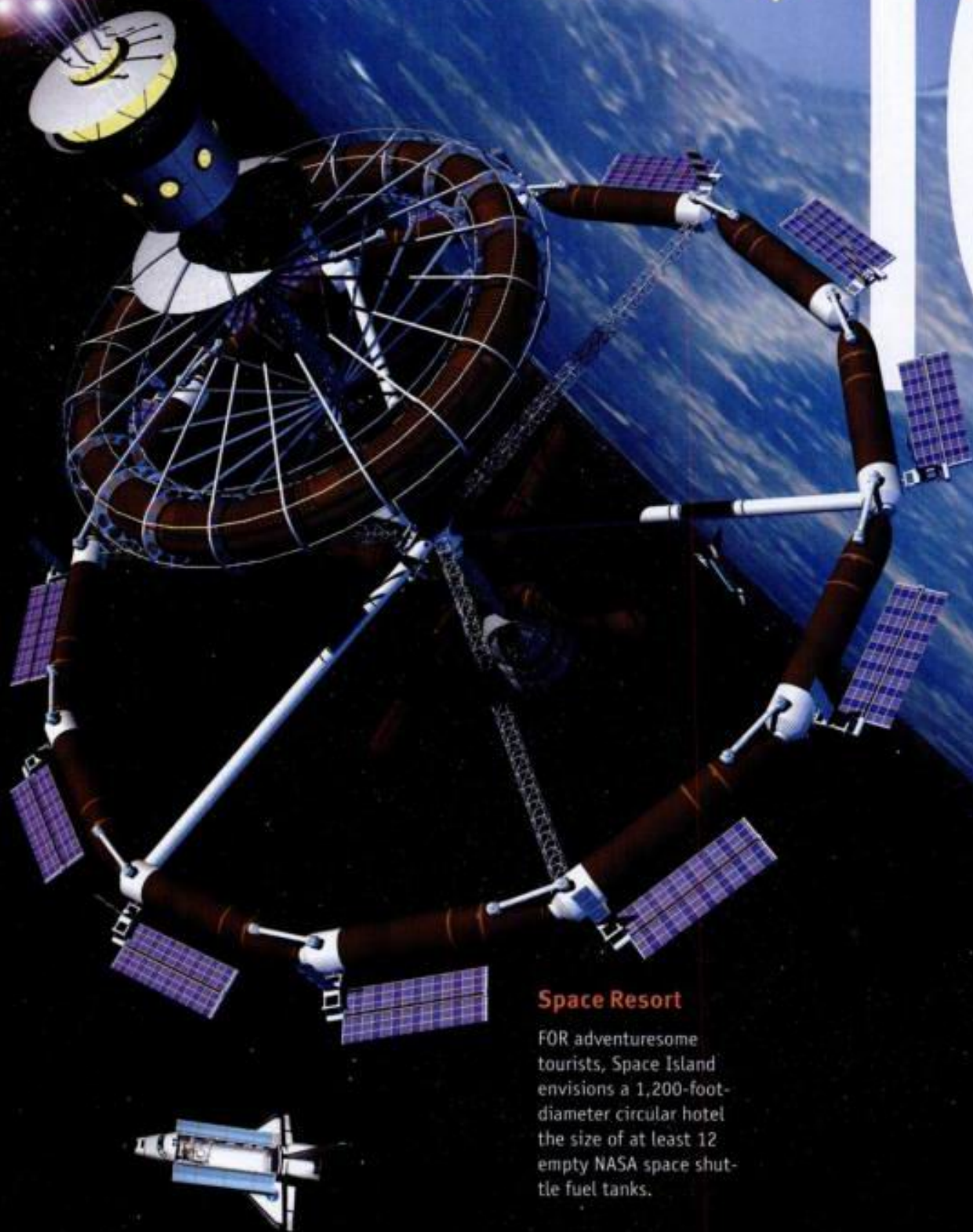
Electric current

Propulsive magnets on the sides of the track rapidly switch their polarity to provide a steady push. For example, consider a fixed "north" magnet on the train. Since north magnets are attracted to south magnets, the track's magnets will rapidly switch polarity to ensure that there is always a south magnet directly in front of the north magnet on the train, pulling the train along even when it's moving at 4,000 mph.

2,000 to 3,000 feet below sea level



The 10



Space Resort

FOR adventuresome tourists, Space Island envisions a 1,200-foot-diameter circular hotel the size of at least 12 empty NASA space shuttle fuel tanks.

Illustration by James White

WHAT'S NEXT: space

And you
find Europe
expensive!
Some tour
companies
want to
send you
into orbit.

By Dan Cray

00 Mile Club

CAREFULLY GRABBING a handrail, Gene Meyers ignores the unsettling movement of the planks beneath his feet and gingerly strolls the second floor of a two-deck chamber, pointing out the colorful walls, attractive curtains, and modest beds. The nearby offices, he says, aren't nearly as charming as the living quarters, since they were designed for functionality, but they nonetheless offer a friendly ambiance you'd never find on, say, the government-built International Space Station.

Of course, there's still a noise problem to resolve: The hustle and bustle of other people and the clanging of nearby doors and instruments are painfully obvious through the thin-walled steel of the superstructure. Still, as Meyers arrives at a poster-sized viewing window, it becomes clear why experiencing this environment is worth putting up

with a few minor annoyances: Beyond the glass, a breathtaking field of stars frames the brilliant blue hues of Earth's Pacific Ocean and the adjoining North American continent.

The informal tour might seem like a perfect evening aboard an orbiting space hotel... only Meyers isn't in a hotel, and he isn't in space. Instead, he's aboard the *Queen Mary*, a retired ocean liner docked in Long Beach, California. In effect, the liner and its cruise ship brethren may be the closest equivalent to the environment space tourists will encounter at the world's first orbiting hotel. According to Meyers, director of the Space Island Group in West Covina, California, that day could come as early as 2007, the year Space Island's consortium of aerospace engineers and researchers plans to assemble the world's first privately financed space station.

Until recently, the notion of vacationing in space seemed as landlocked as the docked ocean liner. Skeptics argued that without a reusable launch vehicle capable of cutting today's \$10,000-per-pound price tag to reach space by 90 percent, planning a station was like placing the celestial cart before the horse.

But that may all change next spring, when Amsterdam-based MirCorp sends millionaire Dennis Tito to Russia's Mir as America's first paying space tourist. (A Japanese television journalist and a woman from England each paid \$10 million for similar "vacations" last year.)

Space enthusiasts say the resulting publicity promises to spark the interest of investment capitalists. "MirCorp is putting reality into space tourism," says Meyers. "All of a sudden, people who don't follow

41%
would pay \$50,000
or more for a
week in space

POLL FLASH

62,000 miles

SPACE ELEVATOR

Most of a rocket's fuel is spent blasting through Earth's thick atmosphere and out of the planet's strong gravitational field. But here's an alternate strategy for getting payloads up to space: Construct a 62,000-mile-long cable jutting straight out from the equator, hold it in place with centripetal force, then lift satellites and spacecraft out of the atmosphere with a giant freight elevator. One major hang-up: Cable strong enough to support the system does not yet exist, though it could be made from carbon nanotubes.



Propellant tanks

Orbital-correction engine

THE SPACE ANCHOR

Communications antenna

Braking motors

Launched to a geosynchronous orbit, the 45-ton anchor deploys its carbon-fiber-filament payload to Earth's surface. Engineers attach the filament to a base station floating west of the Galapagos Islands. The anchor keeps itself in place using fuel stored in its 8-foot-diameter propellant tanks.

THE CLIMBER

Solar panels

Track and roller system

Laser-collection dish

Once the filament is in place, it must be strengthened. More than 200 "climbers" will add layers of carbon-nanotube fiber to the tether, until it widens into a 3-foot-diameter cable. An infrared laser fired from Earth will beam energy to the climbers.

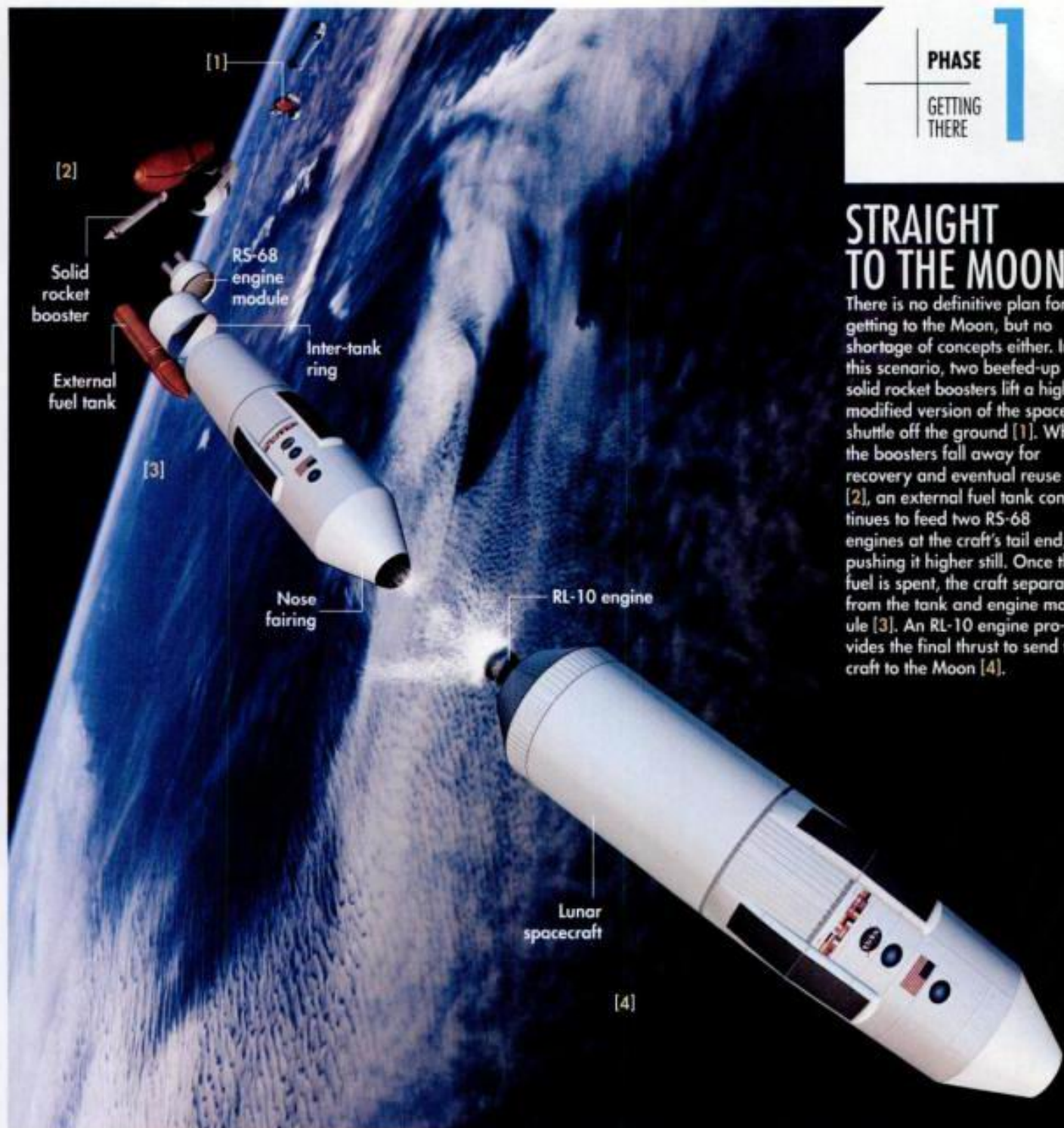
THE ISS

By comparison, the International Space Station orbits a measly 250 miles above Earth's surface.



STRAIGHT
TO THE MOON

There is no definitive plan for getting to the Moon, but no shortage of concepts either. In this scenario, two beefed-up solid rocket boosters lift a highly modified version of the space shuttle off the ground [1]. While the boosters fall away for recovery and eventual reuse [2], an external fuel tank continues to feed two RS-68 engines at the craft's tail end, pushing it higher still. Once the fuel is spent, the craft separates from the tank and engine module [3]. An RL-10 engine provides the final thrust to send the craft to the Moon [4].



a permanent settlement, perhaps even capable of supporting tourists or colonists.

We're a long, long way from that dream right now, though. For one thing, NASA doesn't have a vehicle capable of taking astronauts and their gear to the Moon. The president has directed NASA to begin developing a spacecraft called the Crew Exploration Vehicle, or CEV. But it could just as easily be called the TBD, because Bush and NASA administrator Sean O'Keefe haven't offered any specifics about what the vehicle will look like or how it will work. "We've got to avoid getting fond of a design," O'Keefe said shortly after the president's speech.

There is no shortage of ideas about how to build a Crew Exploration Vehicle. "If you piled up every study [NASA] has

done on getting to the Moon, it would get you to the Moon," says John Pike, director of Globalsecurity.org. "This whole thing has been studied to death. The only thing they have not looked at is [sending] midgets."

But given the time constraints imposed by the president, and NASA's poor track record for developing a shuttle replacement (the agency spent billions on the failed National Aerospace Plane, the Delta Clipper and the X-33), it seems likely that NASA will settle on a relatively old-fashioned vehicle, one

[CONTINUED ON NEXT PAGE; TEXT CONTINUES ON PAGE 66] ►

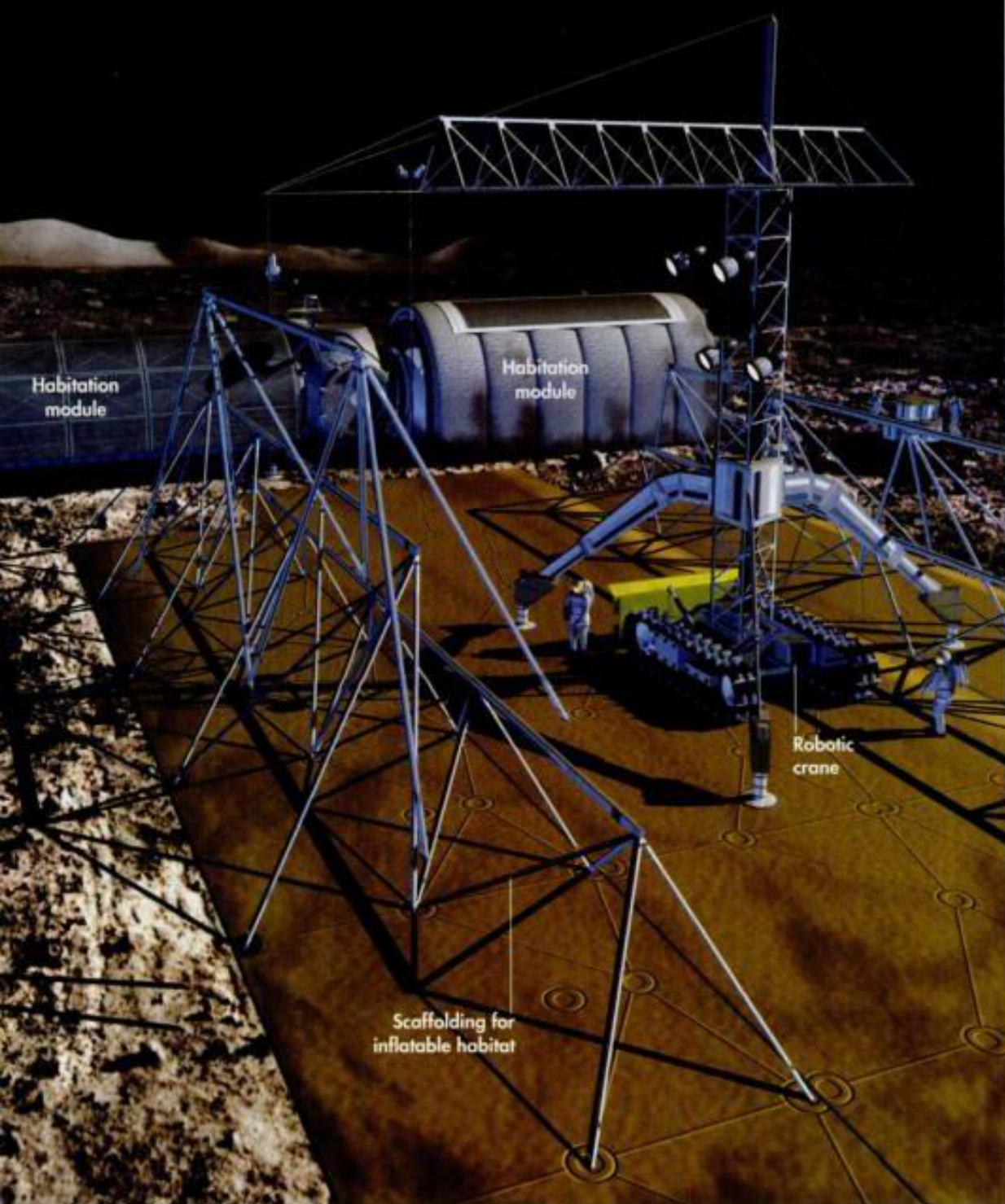


Want to buy an acre on the Moon? popsci.com/exclusive

PHASE

SETTING
UP CAMP

2



A ROBOTIC ASSIST

Building a lunar dream home will require more than manpower. Astronauts will supervise, but robots will do the "heavy" lifting. Here, a robotic crane erects ribs that will serve as the framework for an inflatable habitat. No equipment goes unused: Landers from previous cargo missions have been converted into habitation modules; one (back right) has been covered with a soil-filled wrapping to shield astronauts from radiation.

PHASE
GETTING
TO WORK

3



MOON-BASE LANDING

As a new crew of six nears the surface, the lander's reaction-control system keeps the craft steady while tail-mounted engines slow its descent. The spacious base now includes three additional radiation-shielded modules and a central inflated habitat. Several nearby fuel plants process frozen subsurface water into liquid hydrogen and oxygen: rocket fuel for the trip home. When astronauts leave base to work or explore, they travel in a pressurized rover. Energy for the base comes from an offsite nuclear reactor—most likely resting in a crater for radiation shielding.

SPACE

THE GREEN SIDE OF THE MOON

Scientists design a self-sustaining lunar habitat that would make Al Gore proud

ASTRONAUTS will probably miss out on the luxurious quarters and gourmet meals planned for space tourists, but moon living may be cushier than expected. Luna Gaia, a habitat designed by an international team of scientists, engineers and graduate students, provides up to a dozen astronauts with fresh vegetables, fish, spacious rooms and clean drinking water (albeit recycled from their own urine).

The group designed the self-sustaining habitat, which harvests solar energy and reuses all of its waste, while attending the summerlong Space Studies Program at the International Space University in Strasbourg, France. Now, with interest in the moon accelerating thanks to NASA's focus and Google's new Lunar X Prize, Luna Gaia is proving to be more than just an academic exercise. In the past year, the team has presented the plan to several space programs, including NASA, which may incorporate ideas from Luna Gaia into its own lunar outpost, planned for sometime after 2020. "It's a really good stepping-stone toward designing an outpost on the moon," says William Marshall, a physicist at NASA's Ames Research Center.

According to the plans, Luna Gaia will be a complex divided into linked, studio-apartment-size pods. Situated in a crater to limit its inhabitants' exposure to solar radiation, it would include private and social areas, labs and exercise rooms, and greenhouses in which astronauts could grow the food necessary for a balanced diet. Filters, plants and bacteria will turn wash water and urine into potable water. Algae and other greenery turn carbon dioxide into oxygen. Overall, the group estimates, these systems would make Luna Gaia 90 to 95 percent sustainable, meaning fewer service trips, longer visits and a clearer conscience.—GREGORY MOORE

6 STEPS TO CLEAN LUNAR LIVING

FIND A BIG CRATER

Designs call for Luna Gaia to be built in a mile-wide **crater** near the moon's north pole. The crater wall casts a shadow that protects the astronauts from solar radiation.

GO SOLAR

A dozen **mirrors**, each 100 feet wide, sit on top of the crater's rim, an area that's nearly constantly bathed in sunlight. These direct light onto another set of mirrors that focus the beam on a water supply, creating steam that drives a turbine and generates electricity for the base.

INFLATE YOUR BEDROOM

Luna Gaia will consist of several inflatable modules made of Vectran, a flexible material that's more durable than Kevlar and can be compressed in transit to help keep delivery costs down. The **greenhouses** will be transparent, but **living quarters** will be covered with a layer of regolith, or lunar soil, to provide added protection from radiation.

GO FISHING

Tilapia are high in protein and thrive in a crowded **tank**. Astronauts will also dine on hydroponically grown wheat and a variety of vegetables, such as spinach and potatoes. The same algae that cleans up the crew's water will be a good source of protein.

URINATE OFTEN

Urine runs first through an ion-exchange filter that removes some contaminants and then into the **algae tanks**, where the algae drink it up and release water vapor that a condenser liquifies. This water either runs back to the crew quarters for washing or is further purified to make it drinkable.

REUSE EVERYTHING

Several different strains of bacteria break down feces into water, minerals and ammonium. These materials are converted into nutrient-rich fertilizer and pumped into the plant, fish and algae chambers.

researchers found no difference in viral load between the two groups.

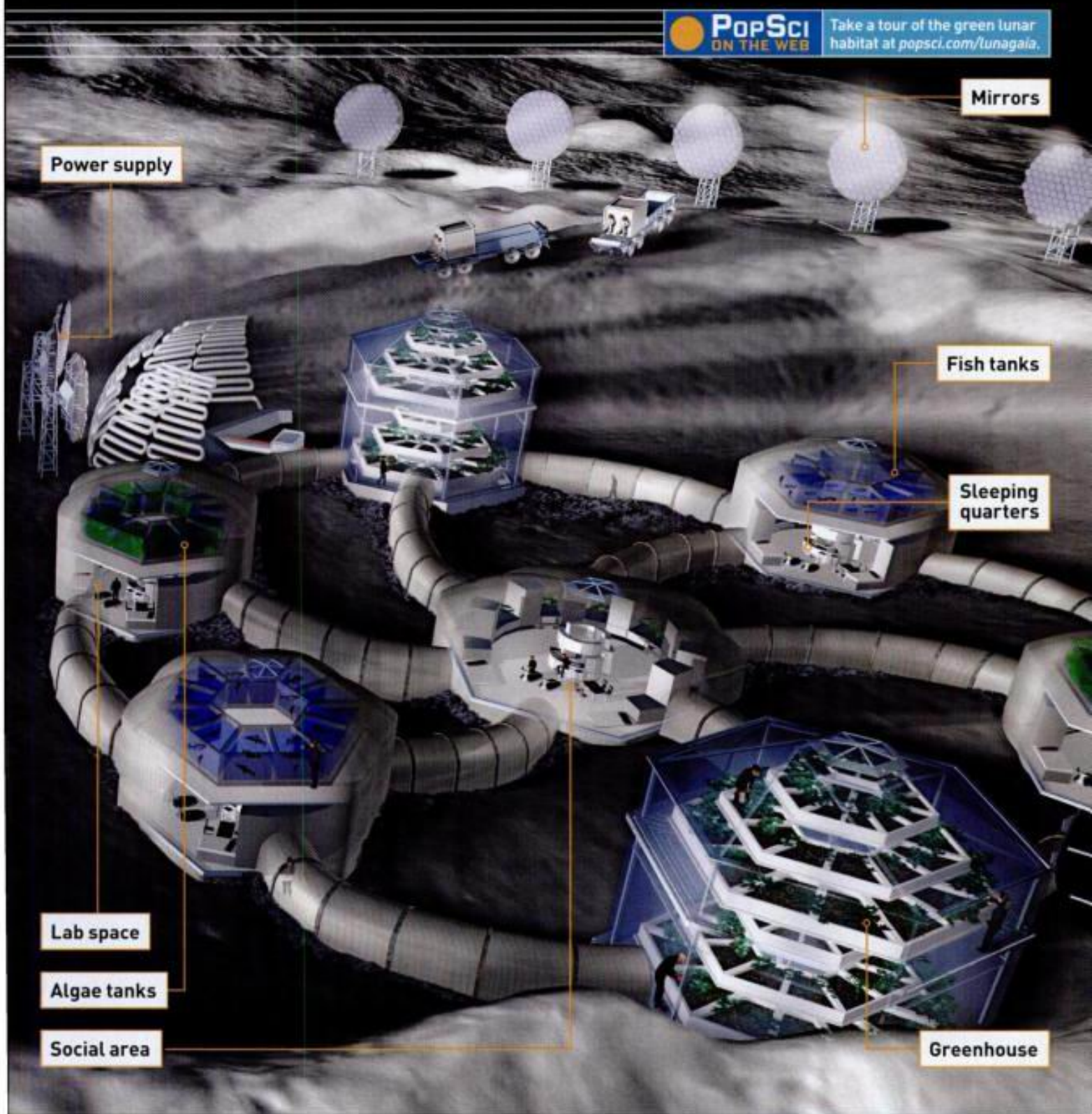
"The question now is whether this was a product failure or a concept failure," says NIAID director Anthony Fauci. "We know this vaccine didn't work. But did it fail because T-cell vaccines don't work?"

One theory lays blame on the weakened cold virus used to deliver HIV genes to human

cells. Most people have at least partial immunity to cold viruses. So the volunteers' immune systems may have snuffed out the modified virus before it could do its job. Or, Fauci notes, this carrier virus may have itself prompted an unhelpful response by calling forth the "helper" T cells that HIV loves to infect.

Yet another possibility is that the HIV genes used in the vaccine proved a poor

match for the HIV strains that infected the volunteers. If so, researchers could simply rejigger the vaccine with more or different genes. The worst-case scenario would be that the response produced by the vaccine matched the infecting strains yet still failed to stop them. "Then we'll have to reexamine why T cells were not as effective as we thought they would be," Corey admits.



The new AIDS vaccine prompts cautious optimism. Says Fauci, "I don't want to use the word 'promising.'"

While researchers continue to parse the failed trial, they are optimistic about the next HIV vaccine trial. Called PAVE 100, the trial will employ a "prime-boost" strategy. Before volunteers receive a modified cold virus similar to the one used in the previous trial, they will get a jab of HIV genes, with the purpose of priming their immune systems for a stron-

ger killer-T-cell attack. Plans call for the trial to enroll 8,500 volunteers in the U.S., Latin America, the Caribbean and Africa.

Fauci remains upbeat but cautious. "I don't want to use the word 'promising,'" he says of the upcoming trial. "This last one was called 'the most promising,' and see what happened."—JESSICA SNYDER SACHS

SENTINELS AT SEA

An offshore screening system will put a 14-mile buffer zone between ports and deadly cargo

TO SECURITY EXPERTS, the immense cargo ships that ferry more than 11 million containers into this country annually are potential Trojan horses—each one could easily harbor a WMD, such as a dirty bomb. Typically, only once the ships have been unloaded is their cargo subjected to random inspections and radiation scans. "There is an urgent need to effectively screen cargo before it reaches the ports," says Charles Meade, a senior scientist at the RAND Corporation, a nonprofit think tank.

Now Florida start-up SeaAway has developed a security system that would move cargo screening 14 miles offshore to the safety of the open seas. The plan calls for pairs of 100-foot-wide platforms anchored outside the world's major ports. Equipped with an array of sensors and unmanned surveillance drones, the system monitors for chemical, biological and nuclear traces as ships travel between the platforms.

SeaAway proposes a passage fee of \$20 per container—roughly double average port fees—to help authorities offset the \$100-million cost of each system. Tax breaks for shippers could help curb costs, notes Steve Kroecker, SeaAway's founder and vice president.

Construction begins this summer on a prototype system. Kroecker won't disclose specifics but says that SeaAway is in talks with officials from four ports in the Caribbean and one on the U.S. eastern seaboard.—MARK SCHROPE

1 PLATFORMS

Floating platforms called Sea Sentinels anchored to the seafloor will include a command center, living quarters for a 15-person crew, a helipad, docking space, and a hangar for unmanned aerial vehicles used in wider surveillance. The facilities will also include space for oceanographic research equipment and laboratories.

2 DETECTION

Ships move between the two large platforms at about 10 knots as antennas read wireless signals emitted by radio-frequency identification, or RFID, tags affixed to each cargo container. Today's transponders can report signs of tampering by detecting when doors open and close after departure inspection, and next-generation sensors will use gas chromatography and other technologies to sniff for radiation, explosives residues, and signs of human cargo, such as urine.

3 SEA HANDLERS

If sensors flag a suspicious container, officials call the Coast Guard, which could use SeaAway's special ship, called a Sea Handler, to retrieve the cargo. The craft relies on suction devices to mate with the ship while a crane transfers the cargo to the Sea Handler's blast-containment chamber. In nuclear or other worst-case scenarios, the submerged chamber can minimize exposure and damage.



4 HULL SCAN

Underwater vehicles use cameras to scan hulls for obvious signs of damage or tampering. For subtler inspections, officials rely on sonar devices mounted to the platforms. These record a hull's acoustic profile and compare the measurements against baseline signatures, stored for all ships.

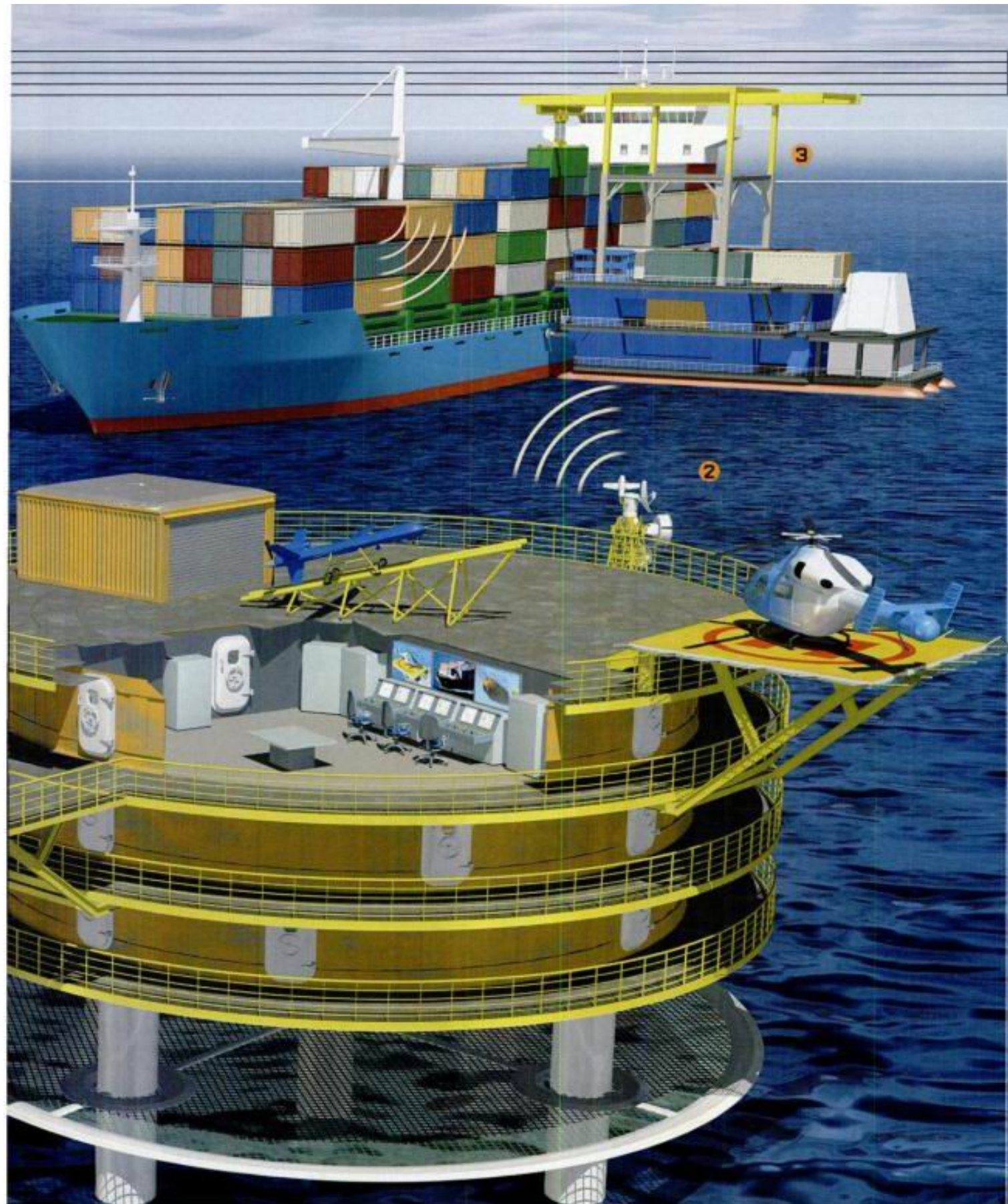
bodies to attack the foreign antigens.

Clausen, who works as a paid consultant to ZymeQuest, sifted through 2,500 bacteria and fungi before pinpointing a gut bacterium, *Bacteroides fragilis*, which produces an enzyme capable of pruning the B

antigen, and a second bug, *Elizabethkingia meningosepticum*, which yields enzymes that are effective against the A antigen. Human clinical trials on the A enzyme are already under way in the U.S. and Europe.

The ability to turn much of the nation's

blood supply into type O could be a boon for hospitals, which use it in trauma cases when there's little time to determine the patient's true blood type. Routine shortages also can put them in a pinch. ZymeQuest's machine churns out eight units of type O



The ability to turn any blood type into type O could be a boon for hospitals.

every 90 minutes. But the technology is far from perfected. Clinical trials must prove that the enzymes leave blood cells unscathed and that they convert all the cells in a unit of blood to type O. If even a few unconverted cells linger, the blood could

provoke an immune reaction. "This is the beginning," says D. Michael Strong, the vice president of the Puget Sound Blood Center in Seattle, one of the country's largest blood banks. "There's still a huge amount of work to be done." —MICHAEL STRONG

HOPPING OUT OF HOT ZONES

When there's no safe escape, call in the Mules: These unmanned aerial vehicles could save lives on the battlefield—and off **BY DAVID AXE**

U.S. TROOPS ARE PINNED DOWN in a crowded city center. Several are wounded and need immediate evacuation. There are miles of labyrinthine roads and thousands of enemy gunmen between them and the nearest base. The threat from rocket-propelled grenades has grounded the big helicopters.

There's one, final hope for these soldiers: the Mule, a compact, fully autonomous medevac aircraft powered by ducted fans—fully enclosed spinning blades that are smaller and more efficient than conventional helicopter rotors. This concept, created by Israel-based Urban Aeronautics, could revolutionize military and civilian emergency care. Within minutes of troops radioing in their GPS coordinates, two drones dart in at 100 mph and land neatly on a narrow rooftop. The casualties are loaded into pods on the UAV's sides—each vehicle can carry two patients—and the fore-and-aft lift fans speed up for vertical takeoff. Once airborne, a medic's voice, piped in by radio, comforts the wounded soldiers, distracting them from the gunfire outside and the disconcerting notion that their rescuers are robots.

The idea, says 56-year-old designer Rafi Yoeli, is a vehicle that can brave dense forests, urban centers and combat zones where choppers, with their vulnerable rotors, can't. Yoeli, who founded Urban Aeronautics in 2001 after decades with companies like Boeing and Israeli Aerospace Industries, is currently building a prototype, aiming for a first flight in 2009. As an unmanned craft, it's both light and able to risk enemy fire. Yoeli is also trying to make it inexpensive, and civilian and military authorities in the U.S. and elsewhere have already expressed interest in his \$1.5-million concept.

The dual-ducted fan configuration used on the Mule is derived from failed "flying jeep" experiments of the 1950s. Those early models were doomed by aerodynamic problems, excessive weight and ducted fans that were too weak. Yoeli relies on new lightweight composite materials, sophisticated autonomous flight software and a patented duct design that boosts the fans' efficiency.

CONTROL The Mule uses ultraefficient ducted fans—basically, fully shrouded helicopter blades—to lift off vertically. Vane systems channel thrust in any direction, allowing the Mule to move sideways and forward and backward without rolling. If the front and back rotors change their relative speeds, the result is a yawing movement to the left or right.

TURBINE POWER

A single Rolls-Royce 250-C30 turbine helicopter engine powers the counter-rotating, three-bladed fans in front and back. The engine exhausts through the top of the fuselage.

GROUNDING

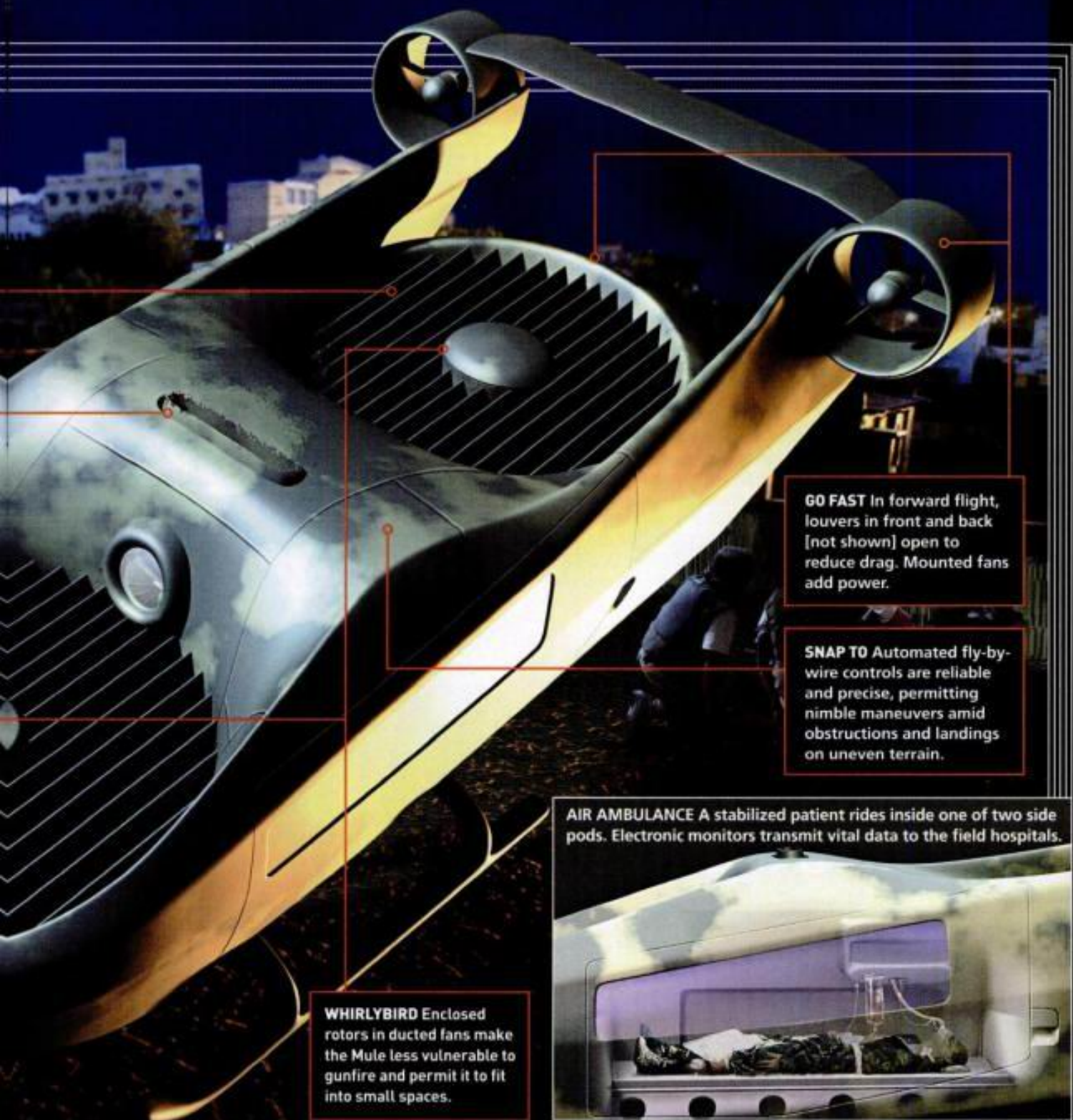
CLEARED FOR
TAKEOFF

0005 OF PRODUCTION

The key is a series of directional vanes on both the top (inlet) and bottom (outlet) of the fans. This type of "vectored thrust" steers the craft using directed airflow instead of control surfaces. "It gives you six full degrees of movement," says Janina Frankel-Yoeli, Rafi's wife and marketing director.

Urban Aeronautics faces several hurdles. "Ducted fans have been around for years," says Bob Behler, a retired Air Force general who once flew medevac aircraft and now works for the MITRE Corporation, which conducts technical research for the government. "They're very efficient, but

PETER BOLLINGER



GO FAST In forward flight, louvers in front and back [not shown] open to reduce drag. Mounted fans add power.

SNAP TO Automated fly-by-wire controls are reliable and precise, permitting nimble maneuvers amid obstructions and landings on uneven terrain.

WHIRLYBIRD Enclosed rotors in ducted fans make the Mule less vulnerable to gunfire and permit it to fit into small spaces.

AIR AMBULANCE A stabilized patient rides inside one of two side pods. Electronic monitors transmit vital data to the field hospitals.



reliability is questionable with vectored thrust." Nevertheless, Behler says that ducted-fan aircraft are great for urban operations. "You've got to have something that travels slowly and can maneuver around obstructions," he explains. He remains concerned, however, about not having a medical attendant with the patient.

Frankel-Yoeli agrees, up to a point. "For regular evacuation, it's certainly not the preferred means," she says. "But if the casualty is in critical condition and you have no other means of getting them help, it's not a difficult question."

MULE UNMANNED MEDEVAC

PURPOSE: Unmanned emergency medical evacuation

MANUFACTURER: Urban Aeronautics

DIMENSIONS: 17 ft. long x 7 ft. wide x 6 ft. tall

MAX. TAKEOFF WEIGHT: 2,400 lbs.

TOP SPEED: 100 mph

CAPACITY: Two patients

COST: \$1.5 million



SEE MORE PICTURES AT
popsci.com/muleuav

THE MOST ADVANCED JET FIGHTER

The Marines' new ride, the F-35B, or Joint Strike Fighter, is the first stealthy, supersonic jet that can slow nearly to a stop in mid-flight and set down anywhere

BY BILL SWEETMAN

1. WHY BUILD IT?

The 400 short-takeoff/vertical-landing (STOVL) F-35Bs ordered by the Pentagon will replace both the F/A-18 Hornet and the British-built Harrier STOVL fighter, which is slow, hard to fly and not stealthy. The F-35B lets Marines launch missions from small ships instead of Navy carriers.

POWER The 43,000-pound-thrust F135 turbofan is the most powerful engine ever produced for a fighter jet (turn the page to see inside it).

STRUCTURE The plane's high-strength, lightweight titanium and carbon-fiber airframe withstands high G-forces.

RADAR STEALTH Its geometric shaping, structural materials, and integrated airframe and propulsion design mean that on radar, the F-35B is roughly the size of a golf ball.

INTAKE This so-called diverterless supersonic inlet, which slows airflow to subsonic speeds before it enters the engine, eliminates many moving parts formerly used for the same function.

3. HOW DOES IT TAKE OFF?

Although the F-35B can land vertically, it needs a running start—as little as 300 feet—to take off. It begins its takeoff roll with the main engine pointing back. At a paltry 80 knots, the engine nozzle and lift-fan exhausts all swing halfway down to give the plane vertical lift and send it airborne.



IN MOTION The standard F-35 during a January test flight

ILLUSTRATION: NICK KALOTERAKIS PHOTOGRAPH COURTESY LOCKHEED MARTIN

2. WHEN WILL IT FLY?

A prototype, the X-35B, tested the plane's unique vertical lift system in a brief series of flights in 2000. The first production F-35B will fly early next year and should enter service in 2012. The first conventional (non-vertical-lift) F-35A began test flights last December.

LOCKHEED MARTIN F-35B LIGHTNING II

SIZE: Length, 51 ft.; span, 35 ft.

WEIGHT: 55,000 lbs.

COST: \$110 million each

MAX. SPEED: 990 mph

CRUISING SPEED: 600 mph

RANGE: 450 nautical miles

FORWARD THRUST: 43,000 lb.-ft.

VERTICAL THRUST: 15,700

lb.-ft. from the main engine,

20,000 lb.-ft. from the lift

fan, and 3,700 lb.-ft. from

roll posts under the wings

WEAPONS: Two 1,000-lb.

Joint Direct Attack Munition

GPS-guided bombs and two

AMRAAM air-to-air missiles;

25mm four-barrel Gatling cannon

MIN. TAKEOFF DISTANCE: 300 ft.

LANDING DISTANCE: 0 ft.

MORE INFO: jsf.mil

COCKPIT The flight controls automatically change function as the plane begins to land vertically. A helmet-mounted display tracks objects wherever the pilot looks.

VERTICAL LIFT This lift fan draws power from the engine to keep the airplane in a hover.

SENSORS The Electro-Optical Distributed Aperture System can track threats in 360 degrees and enhances the pilot's field of view.

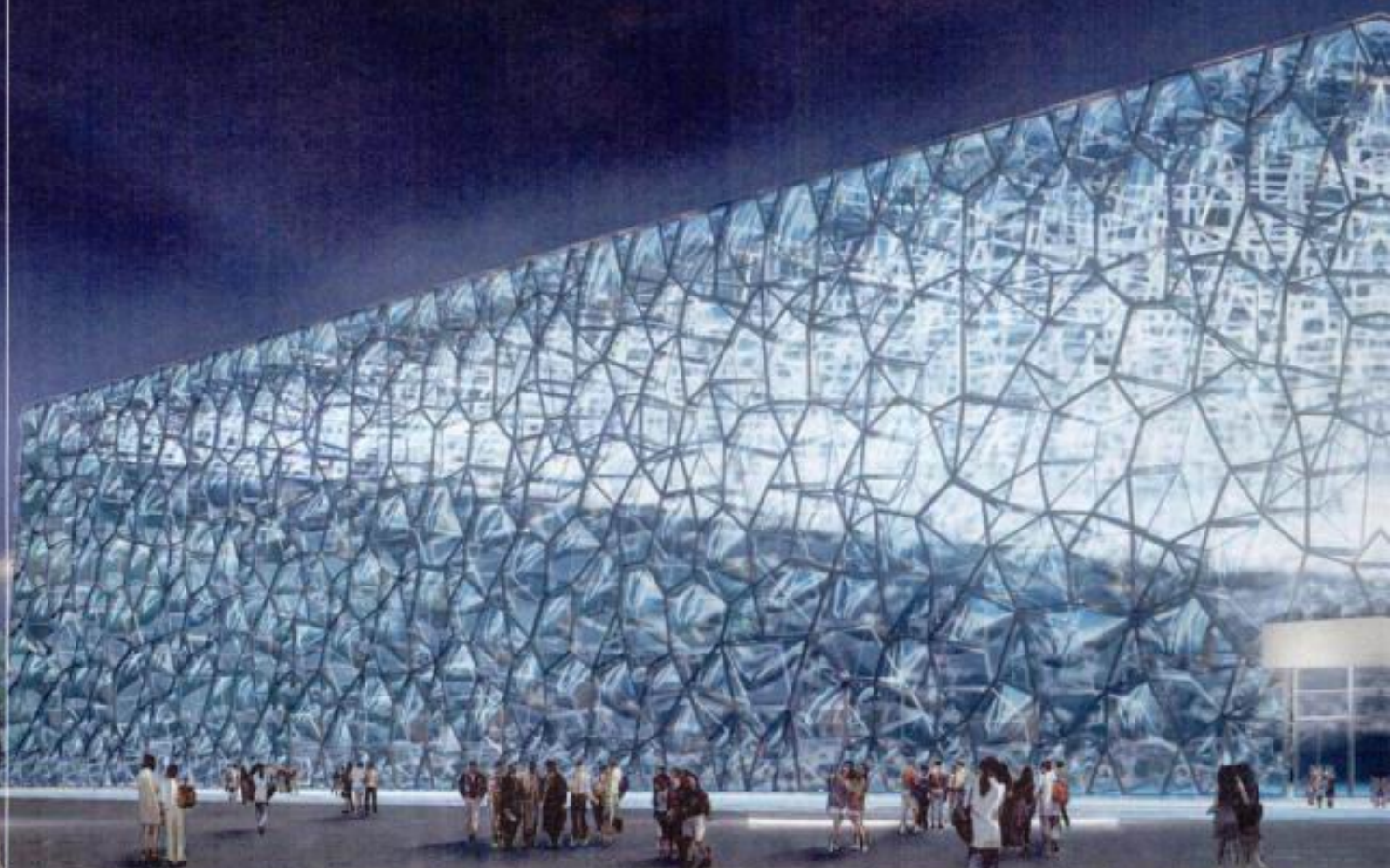
WEAPONS AMRAAM missiles launch from the internal weapons bay.

RADAR The Active Electronically Scanned Array radar uses hundreds of transmitters and receivers to track multiple targets at once and to make the plane harder to detect.

4. TURN THE PAGE TO SEE HOW THE F-35B LANDS VERTICALLY

**THIN SKIN**

China's new Olympic swimming center features transparent foil in lieu of windows.



ENGINEERING

"THE WATER CUBE" BEIJING NATIONAL SWIMMING CENTER

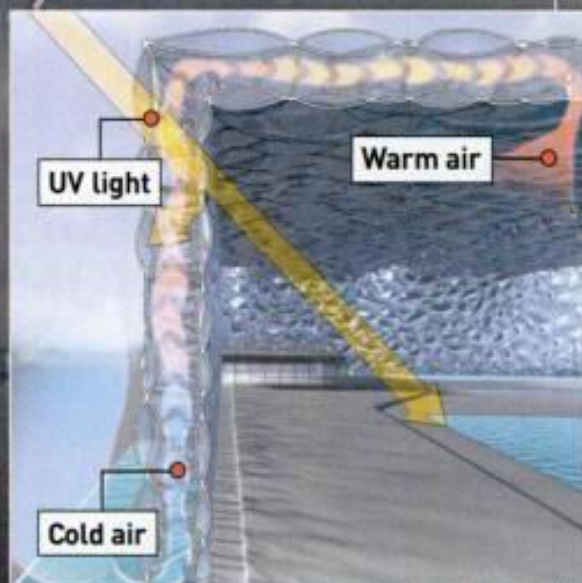
A BUILDING MADE OF BUBBLES

THE OFFICIAL SWIMMING FACILITY of the 2008 Olympics in Beijing, China, will span 7.8 acres, house five pools, and seat 17,000 spectators, yet it doesn't contain a single steel cable, concrete column or structural beam. Instead its walls and ceilings are composed of a network of slender steel pipes linked together by 12,000 load-bearing nodes. These nodes evenly distribute the weight of the building, making

it strong enough to withstand Beijing's most severe earthquakes. Plastic foil—just eight one-thousandths of an inch thick—covers the entire structure like Bubble Wrap. It lets in more light and heat than glass does, helping to keep the pools warm and slashing energy costs by 30 percent. Construction will finish up this year, with the official opening slated for the Summer Olympics. arup.com



BRIGHT IDEA Ultraviolet light penetrates the walls' plastic insulation, heating cool air as it's drawn into the building. This creates a cozy greenhouse effect that keeps the pool warm.



ENGINEERING

RIDIN' HIGH A few sheets of glass are all that keep visitors on the Skywalk from a 15-second free fall to the canyon floor.



MRJ ARCHITECTS, LOCHSA ENGINEERING & APCO SKYWALK

A RARE VIEW OF THE GRAND CANYON

EASILY THE MOST audacious tourist attraction of the year, the Skywalk U-shaped footbridge extends 65 feet beyond the lip of the Grand Canyon, with zero support from below. Set for completion next month, the \$30-million balcony consists of two curved, parallel steel beams joined together by a 2.5-

inch-thick glass floor, offering a view of the ground nearly three quarters of a mile below. To secure the bridge, 96 steel rods bore 50 feet into the canyon wall just beneath the visitors' center, and a set of 1.6-ton steel dampers brace the structure against wind gusts up to 90 mph.

www.destinationgrandcanyon.com

HYDRO ORMEN LANGE/
LANGELED PROJECT

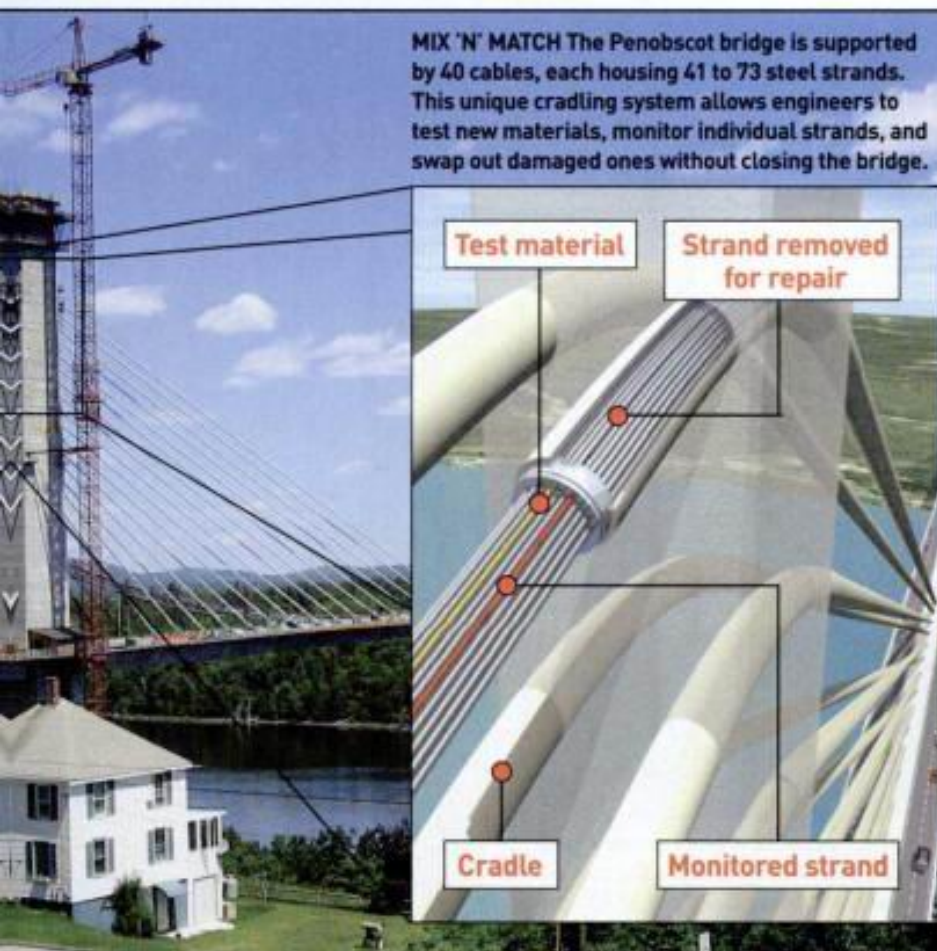
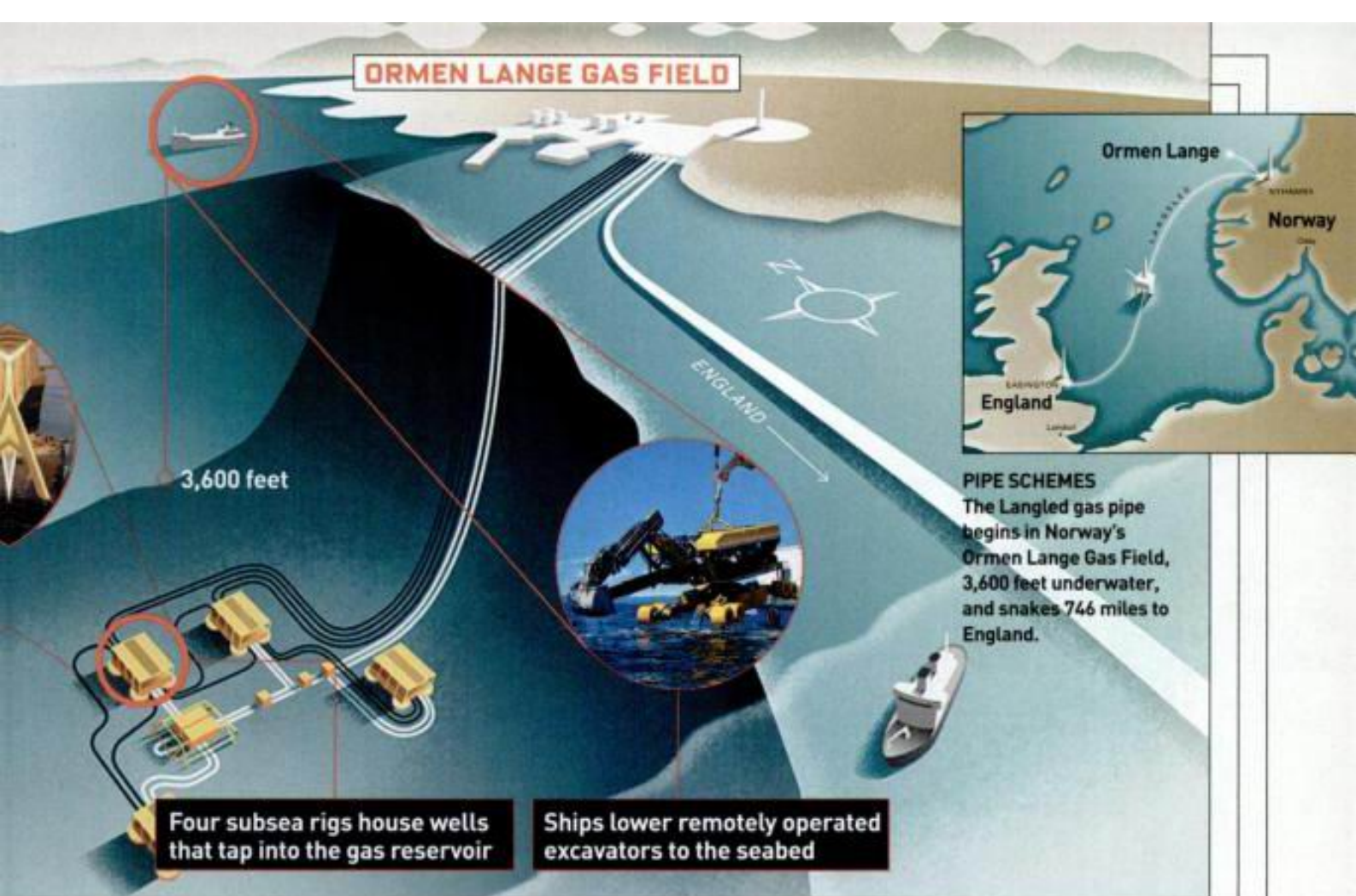
THE LONGEST PIPELINE OVER THE TOUGHEST TERRAIN

EARLIER THIS YEAR, divers finished welding a major section of the 746-mile Langeled underwater gas pipeline, which snakes from a giant gas field in the Norwegian Sea to the U.K. The final step is to lay pipe through the Storegga Slide, a ragged maze of 200-foot peaks and 35-degree hills. To do it, engineers are now peppering the seabed with 400 acoustic transponders. These will help create 3-D maps to guide shipboard technicians controlling two remotely operated vehicles as they clear away boulders and dig trenches 3,000 feet below. When gas starts flowing next year, the \$10-billion pipeline will provide one fifth of the U.K.'s natural gas.

hydro.com/en

MAINE DECK The western tower of the Penobscot Narrows Bridge includes an elevator that leads to an observatory 420 feet above the river.





FIGG ENGINEERING PENOBSCOT NARROWS BRIDGE

A BRIDGE YOU CAN FIX WITHOUT STOPPING TRAFFIC

IN TRADITIONAL cable-stay bridges, the cables that hold up the roadway pass through the support towers in a big bundle. That not only leaves them vulnerable to friction and corrosion, it makes repairs an all-or-nothing affair. Maine's 2,120-foot Penobscot Narrows Bridge, which opened last month, uses a unique cradle system that gives each epoxy-coated steel strand its own one-inch steel sheath. This protective coating keeps the steel from rubbing and allows workers to replace cables one at a time. The entire assembly is pumped full of pressurized nitrogen, an inert gas that fends off corrosion. The \$85-million bridge is expected to last twice as long as its predecessor and will be one of just three bridges in the world with an observatory. waldohancockbridge.com

Retractable roof

Roof panel

7.5hp motor

Track

OPEN SESAME It takes 64 motors 13 minutes to open or close the roof. While opening, motors feed power into the grid.

WALTER P. MOORE ENGINEERS/UNI-SYSTEMS UNIVERSITY OF PHOENIX STADIUM

A STADIUM THAT GOES FROM INDOORS TO OUTDOORS IN A FLASH

THE NEW 63,400-SEAT, \$455-million Cardinals stadium in Glendale, Arizona, features two of the largest moving parts in sports history: the country's first completely retractable grass

field and the first inclined retractable roof. At the press of a button, the 2.2-acre field, which spends most of the year outdoors in a giant steel tray, can be wheeled in on tracks in just over an hour. And the two 550-ton

retractable panels that make up the stadium's roof pump juice back into the stadium's roof pump juice back into the electrical grid as they slide open. Now, if only the long-suffering Cardinals can match the performance. azcardinals.com/stadium



FRESH GREENS Automated tracks roll the Cardinals playing field in and out of the stadium in about an hour. (Other retractable fields can take half a day.)

ALTERNATIVE ARCHITECTURE

THE WALLS

To create each wall section, the builders will construct a scaffold that guides the vines or roots as they grow, forcing them to assume the desired shape.

GROW YOUR SECOND HOME

Designers plant the seeds for a high-tech version of the Swiss Family Treehouse

IF SOLAR POWER and recycled building materials just aren't green enough for you, the brains behind the Fab Tree Hab might have the perfect pad. Architects Mitchell Joachim and Javier Arbona, along with environmental engineer Lara Greden, have designed a house that will grow from a few seedlings into a two-story, water-recycling, energy-efficient abode. The Fab Tree Hab, a mix of ancient and ultramodern technology, isn't merely environmentally friendly. It is the environment.

Instead of building a home out of green materials, the trio figured, why not construct a living, breathing house? "Something that's alive and thriving," Joachim says. They hope to plant the first house within five years, but for now, they're working with Israeli arboriculture firm Plantware, testing techniques for growing the lattice-like weave of vines and roots that will form the walls.

Despite its odd exterior, the house will look normal on the inside. The walls, packed with clay and plastered over, will keep out the rain, and modern technology will be welcome. Yet there are still a few practical kinks to work out. Joachim wonders, for example, how a planning board will react to a house that constantly expands.

Each house will take at least five years to grow, depending on the climate, but Joachim envisions the structures being grown and tended to on a farm. Customers could pick a finished tree habitat and then have it transported to and replanted on a lot within 100 miles. Here, a look inside and out at what's sure to be the greenest house on the block. —GREGORY MONE



nuclear plant, the decommissioned plant would be towed away and replaced with a new one. The reactor and spent fuel would go to a storage facility, but the barge could be recycled.

Yet because the safety of the Russian facility is still unknown, the prospect of resurrecting the Westinghouse idea in the White Sea has drawn protest from environmental groups such as Greenpeace and the Norwegian foundation Bellona. One concern is that a boat could ram the plant and

spill waste into the water. An even bigger fear is that a nasty storm could cut the plant off from the land-based power supply required to run plant operations. Should emergency generators fail, says David Lochbaum, director of the Nuclear Safety Project at the Union of Concerned Scientists, a Chernobyl-like disaster could ensue. In a worst-case scenario, an overheated core could melt through the bottom of the barge and drop into the water, creating a radioactive steam explosion. Such a cloud could do

far more damage than the plume of nuclear fallout kicked up by the 1986 explosion of the Chernobyl nuclear power plant in the former U.S.S.R., Lochbaum notes, because the human body absorbs radioactive water droplets more easily than it does radioactive ash. "Its worst day would be much worse than a land power plant's," he says.

Sergey Obozov, acting director for Rosenergoatom, says that reactors at sea have a proven safety record: The facility would be powered by two 60-megawatt

SEPTIC SYSTEM

Rainwater collected in a basin on the roof will supply the plumbing system, eventually flushing through to a "living machine" outside the house: Bacteria and fish in the pond will consume waste in the water and return it, clean, to the environment.

WINDOWS

Soy-based plastic windows capable of stretching as the house expands will be used in place of flat glass. (Standard plastic, which is derived from petroleum, is a no-no.) At first bubble-like in shape, the windows will gradually flatten as the house grows.

ELECTRICITY

The electricity will probably come from good old-fashioned solar power. The appliances inside will be just like in a typical house. "You won't have a grow-your-own microwave," Joachim jokes.

THE FRAME

Trees of the same species, such as elm or live oak, would be joined to form an arch. After as little as a year, they graft onto one another, forming a single, multitrunk tree.

THE INTERIOR

To insulate the house, the walls will be packed with clay and straw and then covered with plaster to keep out water and pests. The downside is that you may need to replaster every few years as the house grows.

'Its worst day would be much worse than a land power plant's,' one scientist says.

LT-40S reactors adapted from those already in use on three Russian nuclear-powered icebreakers. Yet Cristina Chuen, a Russian nuclear-energy specialist with the

Monterey Institute for International Studies in California, cautions that subtle performance differences might arise when running the reactor for pure energy generation instead of propulsion, noting that the cooling system remains unproven. Although the technology exists to contain a burning core, Rosenergoatom won't say if the plant—which was designed a decade ago—will include the most modern safety measures.

With a building permit in hand, Rosenergoatom aims to have the facility afloat in

the port city of Severodvinsk in the southeastern White Sea by late 2010. "The Russians have learned a lot about safety from the U.S. Department of Energy, Sweden and Norway—who probably all wish [the Russians] would focus on things other than a floating nuclear power plant," says Chuen, who adds that she wishes the planning process were more transparent. "Maybe it will turn out great, but I just hope they did all the research to make sure it's safe." —BJORN CAREY

TRANSPORTATION

PLANES, TRAINS AND AUTOMOBILES

Not to mention ports, subways and buses. Here, the technologies that will soon safeguard your travel plans

THE FUTURE OF SECURE TRAVEL hinges on seamless, instant communication—and 24/7 autonomous surveillance. Smart sensors will wirelessly monitor the engines of tomorrow's buses for signs of tampering. Toxin detectors will sniff future trains and subways for airborne toxins, then alert the authorities long

before passengers do. Radio transponders will constantly track the whereabouts of luggage, keeping it out of nefarious hands. In-flight cabin cams will transmit real-time images of the shady guy in row 13G to ground control. In other words, wherever you go, the Department of Homeland Security will go with you.



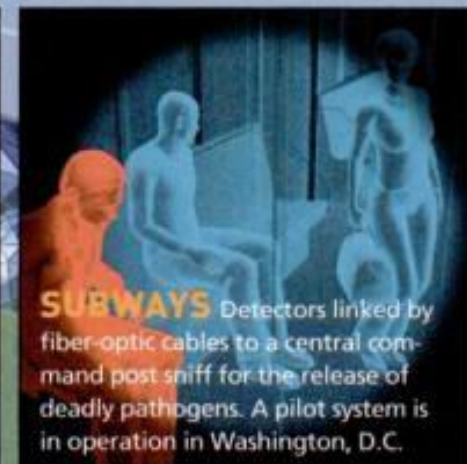
LUGGAGE Radio tags attached to luggage keep tabs on your bags while automated bomb-detection devices check them for explosives. Such tags are already in use at McCarran International Airport in Las Vegas.



PUFFERS New passenger-screening devices installed at 26 airports use blasts of air to dislodge tiny particles on clothing and identify nitrate-based explosives in seconds.



BUSES Sensors attached to engines pick up signs of trouble long before a bomb goes off. Field trials of the sensors are now under way in St. Louis, Missouri.



SUBWAYS Detectors linked by fiber-optic cables to a central command post sniff for the release of deadly pathogens. A pilot system is in operation in Washington, D.C.



CARGO Lawrence Livermore National Laboratory's "nuclear car wash" uses a neutron beam to detect gamma rays that may be emanating from cargo containers.

RADICAL RADAR

A nationwide network of radar stations now in the works by the defense firm Raytheon transmits data—anything from the location of a hijacked plane to images of suspicious passengers—to pilots and ground crews anywhere in the U.S.

SMART WALLS Airports will be ringed by electronic security systems that will include sensor-packed fences, motion detectors and surveillance cameras. Raytheon will install such systems at New York's four major airports in 2008.

LASER GUARDS Infrared lasers mounted to a jet's fuselage deflect heat-seeking missiles. One system is currently in tests on an American Airlines 767.

(CONTINUED FROM PAGE 33) technology designed to make you feel better," says Bruce Schneier, author of *Beyond Fear: Thinking Sensibly about Security in an Uncertain World*. He points to high-tech protection poured into landmarks, from the White House to local city halls, that he claims diverts terrorist attention to "softer" targets like subways and stadiums. But the government seems to have taken the point. Its ever-expanding homeland-security measures cover not just big targets but the nation's broader vulnerabilities as well. Here are five of the highest-risk areas, along with some of the technologies emerging over the next few years to defend them.

AIR, WATER, FOOD SUPPLIES

One of the biggest challenges in this area is to develop sensors that can sniff out attacks on everything from crops in fields to air-conditioning systems in public spaces. The Environmental Protection Agency, in conjunction with the Centers for Disease Control and Prevention and the Federal Bureau of Investigation, has deployed a network of miniature toxin detectors in 30 American cities as part of a \$300-million program called BioWatch. The filters collect airborne toxins, which are sent to laboratories for analysis.

Scientists at Lawrence Livermore National Laboratory have pushed this idea further with their Autonomous Pathogen Detection System, or APDS. Inspired by the 1995 Sarin gas attack in the Tokyo subway, APDS can identify chemicals and biotoxins without requiring researchers to gather daily samplings and wait for readouts. Hooked to the ventilation system of a mall, train station or other gathering place, APDS can perform 178 separate samplings of air over a week without human intervention and relay its findings wirelessly to a central lab. It's been tested in New York City and could debut in other urban areas by 2008.

BORDERS, INFRASTRUCTURE

Since 2004, some 60 million visitors to the U.S. have had their two index fingerprints recorded by an optical scanner that checks the information against a



Cover drawing by
Reynold Brown

A racing champion designs a tunnel-shaped

By Alden P. Armagnac

PS photos by W. W. Morris

BECAUSE an inquisitive experimenter sawed a boat in two, tomorrow's ocean voyagers may enjoy unprecedented speed and comfort aboard liners of new design.

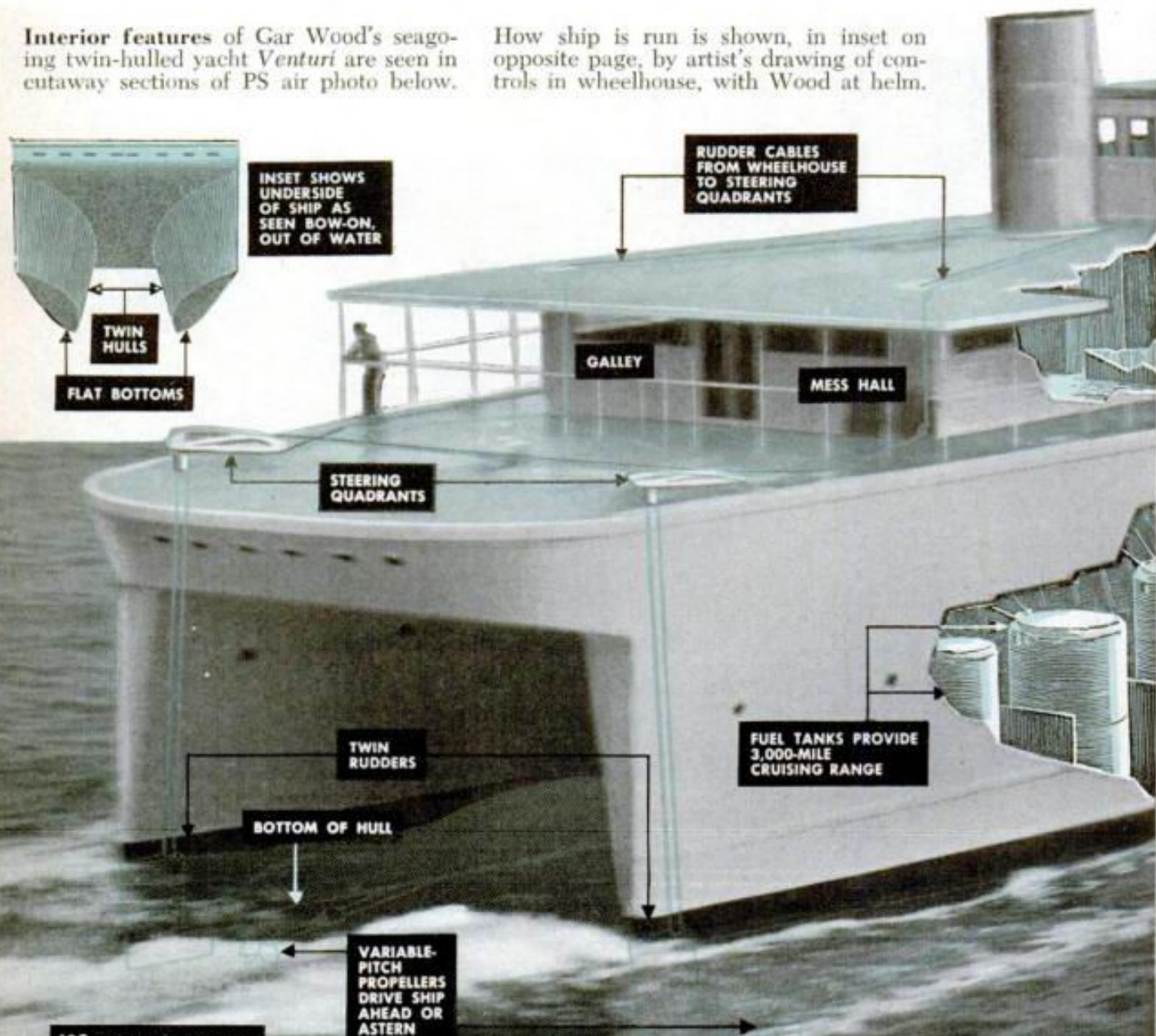
The man with the saw was Gar Wood, silver-haired king of American motorboat racing. He sliced a conventional boat hull

down the middle, transposed the two halves, and joined them with a superstructure. And he found he had a better boat.

Now the 68-year-old inventor envisions a superliner applying this design—a giant floating tunnel 900 feet long. Twin hulls would be bridged by decks with accommodations for at least 4,000 passengers. Four steam turbines, totaling some 120,000 hp., would propel the bizarre ship at 35 to 36 knots, a

Interior features of Gar Wood's seagoing twin-hulled yacht *Venturi* are seen in cutaway sections of PS air photo below.

How ship is run is shown, in inset on opposite page, by artist's drawing of controls in wheelhouse, with Wood at helm.



Gar Wood's Sea Speeder

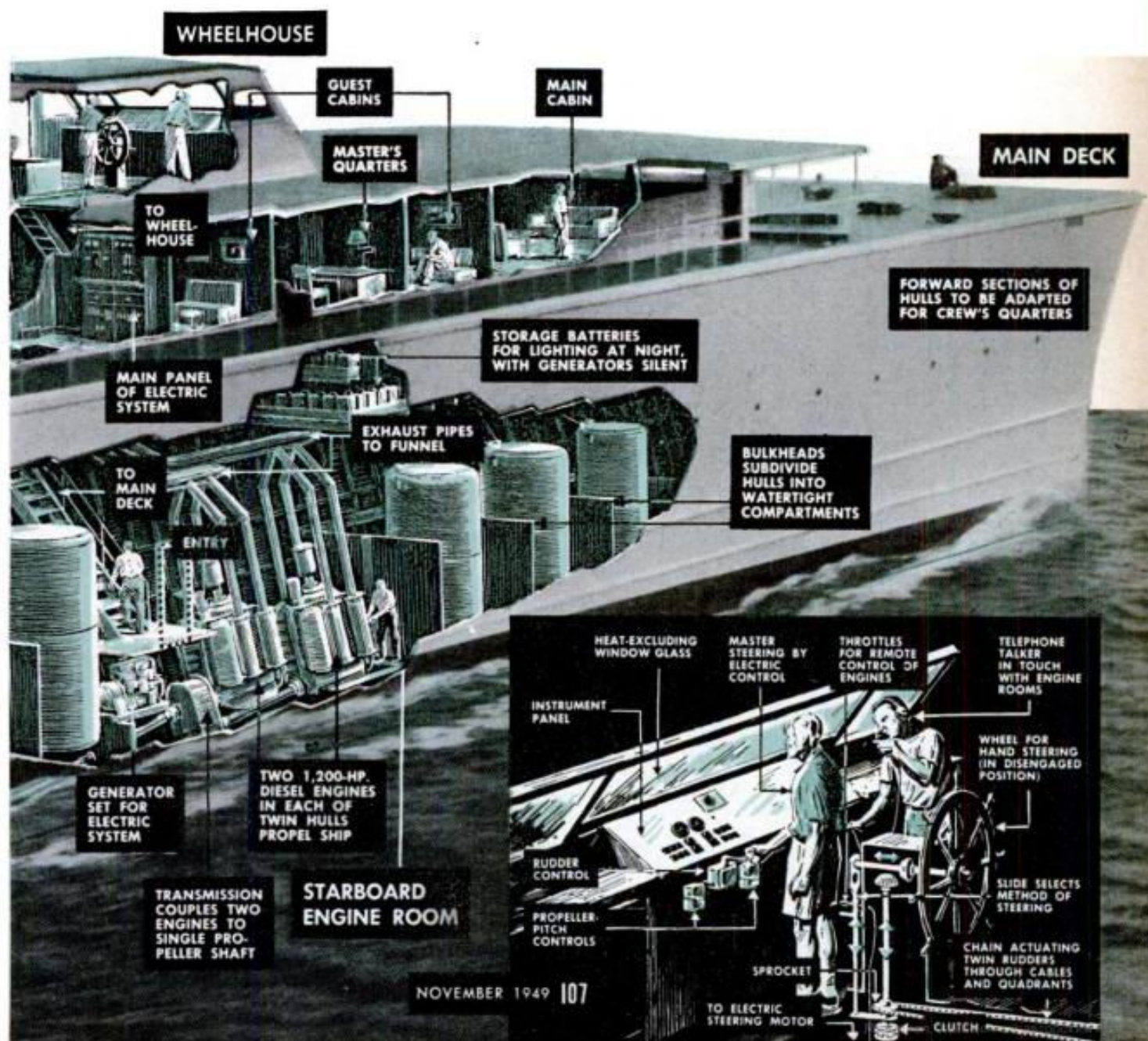
boat that looks like an inventor's pipe dream—but works.

phenomenal pace for commercial vessels. (The 80,000-ton *Queen Mary* uses 200,000 hp. to carry about 2,000 passengers at a top speed of 32 knots.)

Free from rolling, pitching, and yawing, the "tunnel boat" would provide new comfort for its passengers. Since these motions slow an ordinary ship, their absence would contribute to the new liner's top speed and to economy of power and fuel.

A king-size working model, Gar Wood's \$600,000 dream boat *Venturi*, demonstrates the principles of his new design. First publicly exhibited last August in trial runs off Miami Beach, Fla., this radical craft currently serves as a floating laboratory to test and perfect its builder's plans.

Pictures don't prepare you for the impressive size of the big, white, brown-roofed, silver-funneled ship. The *Venturi* ➤

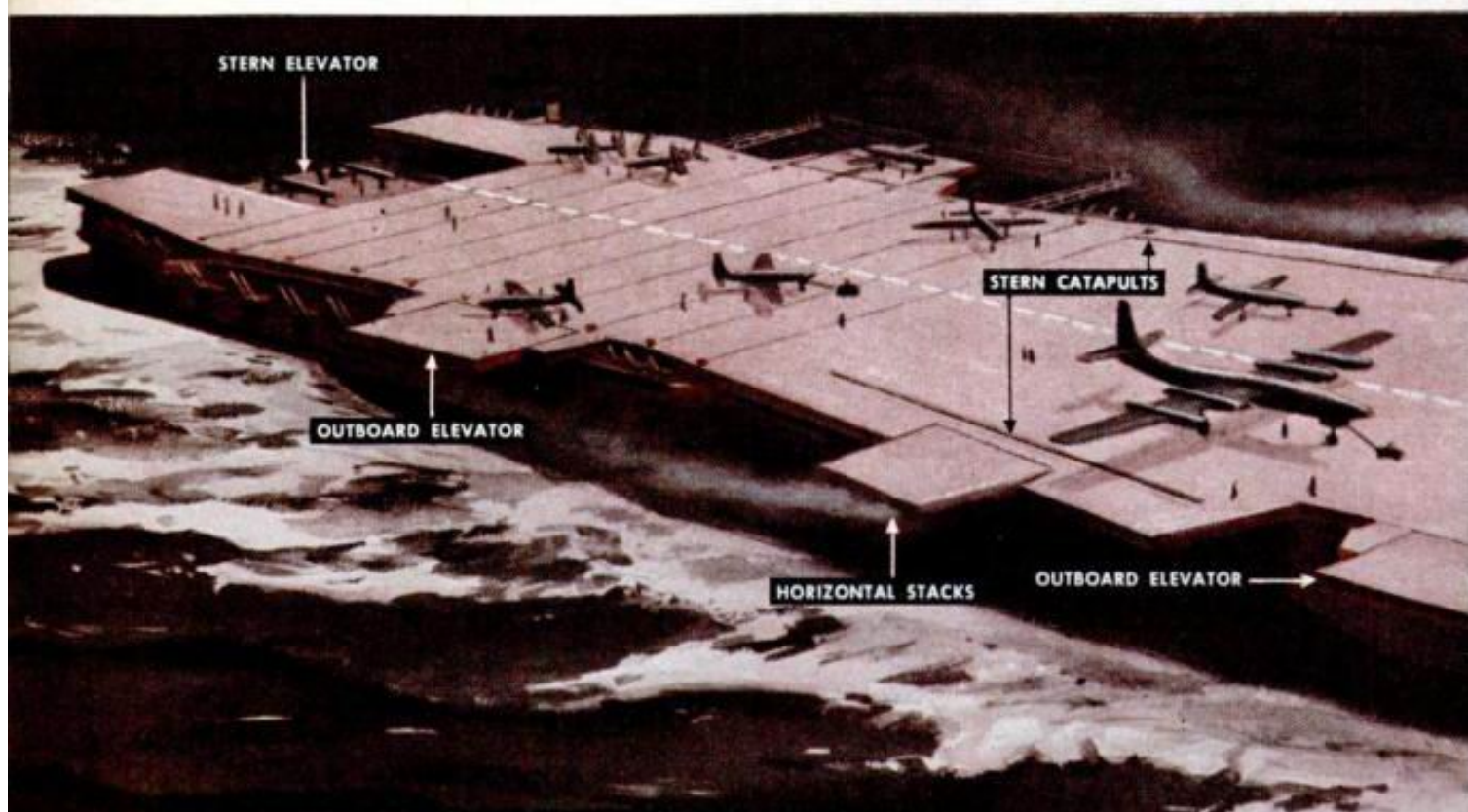




Why the Navy Wants Supercarriers

By Phil Gustafson

Drawings by Ray Pioch and Walter Popp



First flattop ever designed from scratch for jet bombers, the new 65,000-ton CVA-58 will carry planes nearly as big as B-29s, says the Navy. They could drop the A-bomb, pin-point vital targets, stage "airphibious" infantry from nearby bases, or put ashore helicopters full of Marines. The islandless flight deck provides a five-acre airfield nearly a fifth of a mile long. Four catapults, served by five deck-edge elevators, will speed launching of planes.



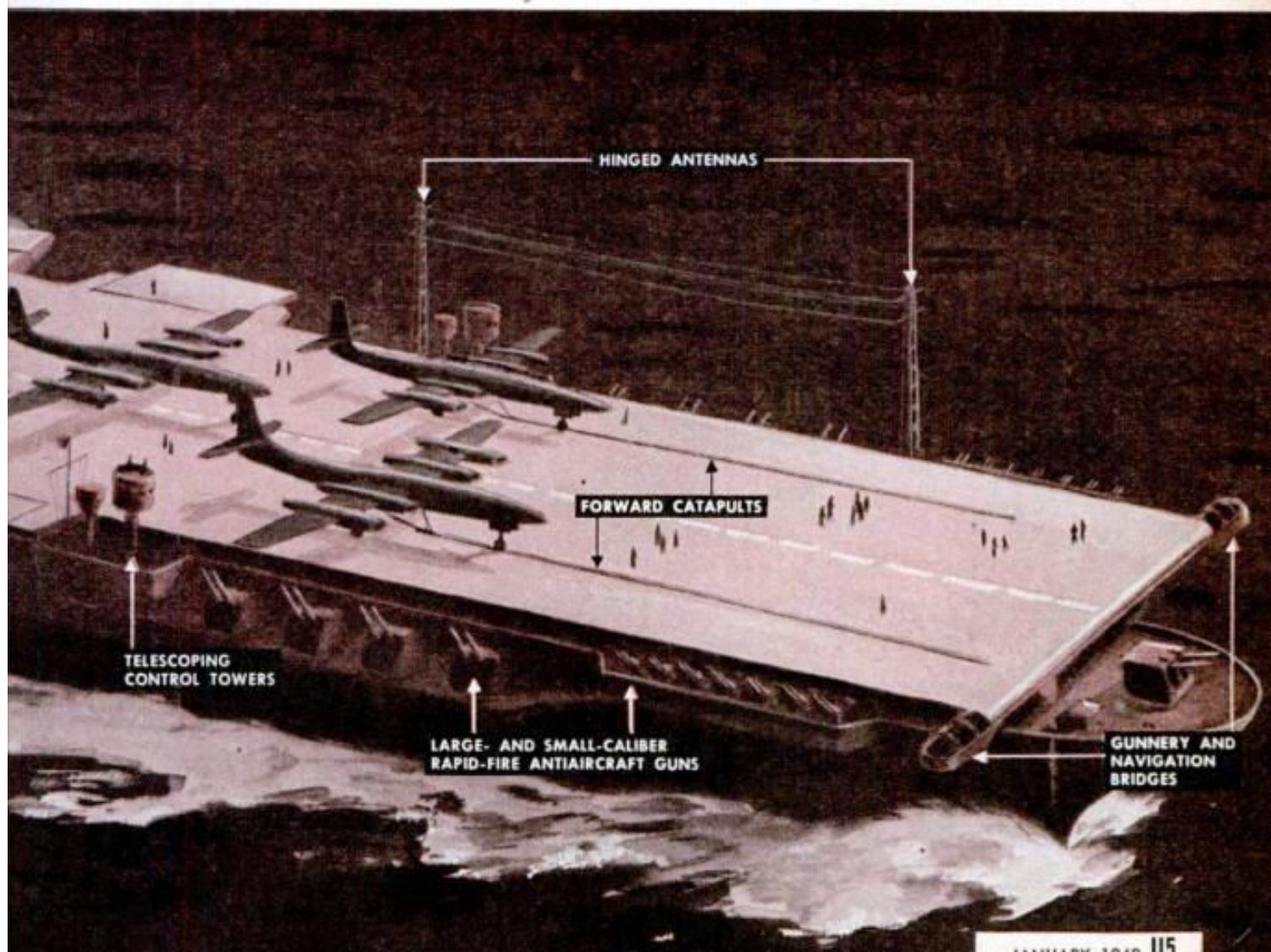
***Jet planes, and bigger planes, call for a fresh
start in carrier design as well as bigger ships.***

EARLY this year, the keel will be laid for a \$124,000,000 super aircraft carrier. Prototype of a 65,000-ton class, the CVA-58 will be *two and a half times as big* as the 27,000-ton Essex class that gave the Japanese navy the business.

Here is a flattop that is really a flattop. The island structure has been shorn away

completely. A flight deck nearly a fifth of a mile long is expected to launch planes of any shape and size the Navy may bring out in the next 20 years.

The supercarrier can be interpreted as the Navy's bid to lug the A-bomb. But the big reason for ships of such size is the coming of the jet airplane.



ESSEX CLASS

OVER-ALL LENGTH: 888 FT.

SUPERCARRIER

OVER-ALL LENGTH: 1,090 FT.

A truly flat-topped flattop, supercarrier CVA-58 will have flush deck a fifth of a mile long.

"Here is a fresh start in fast-carrier design," says Rear Admiral John H. Cassady, Assistant Chief of Naval Operations for Air, whose special job has been to help develop the new flattop. "It is the first of the Navy's carriers to be built from scratch with jet planes in mind. And not only jet planes, but jet planes of a size not yet even on the drafting boards."

Eventually, say the Navy's air-operations officers, these planes will be jet bombers almost the size of the present B-29s and two or three times as fast. Weighing almost 100,000 pounds, they are expected to take off from their seagoing airdromes 1,000 miles from an enemy's coast and fly as much as 700 miles inland to hit their objectives. Compared with this performance, today's carrier planes are mere June bugs of 20,000 pounds, with a combat radius that only recently has reached 700 miles.

"We're thinking about a plane with a combat radius of 1,700 miles right now,"

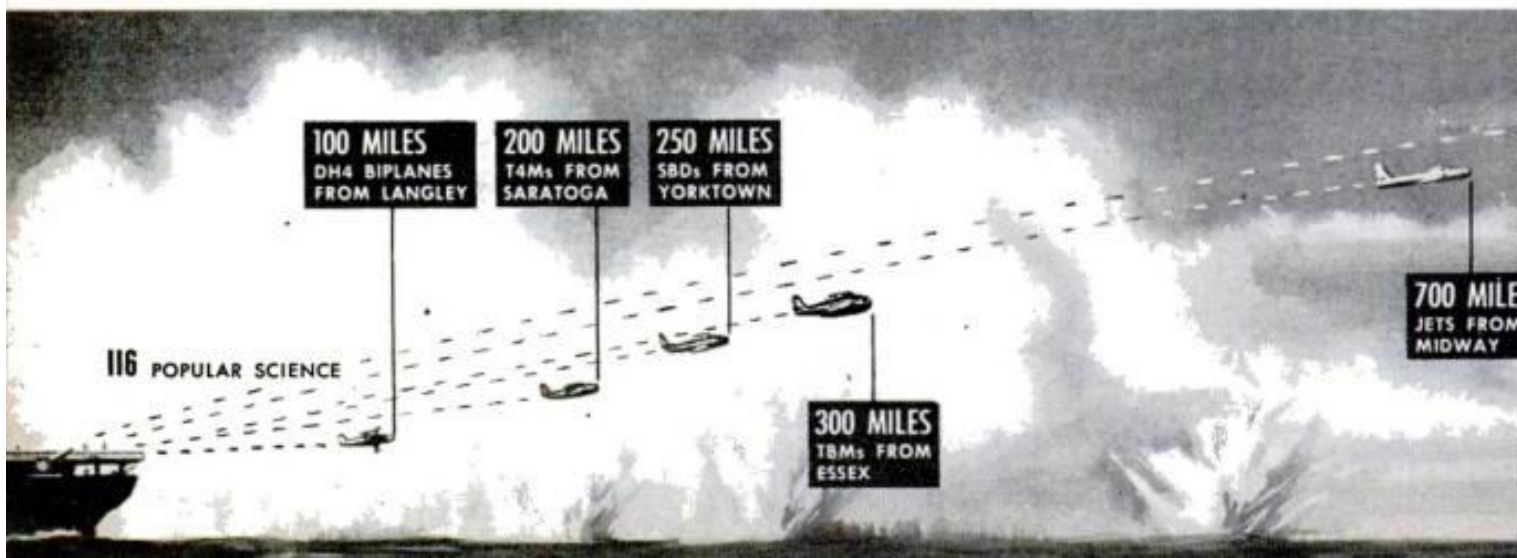
Admiral Cassady told me. "It should be coming out in 1952 or '53, about the time the new carrier is completed. This ship is mighty important; without it the evolution of the fast carrier will be seriously delayed."

The flush deck is but part of the new look that has been coming over carriers since the first time a jet plane sat down on one.

The carrier has been an airfield built around a type of plane with a wicked fan on the nose but only a fishtail in the rear. Now you have a plane with two very dangerous ends—a treacherous suction front and a very hot behind. When a jet engine whines up to shrieking speed, you give the airplane deck space—and lots of it.

The carrier has been a football field with charging lines of plane pushers. Today a tractor replaces the muscle mob.

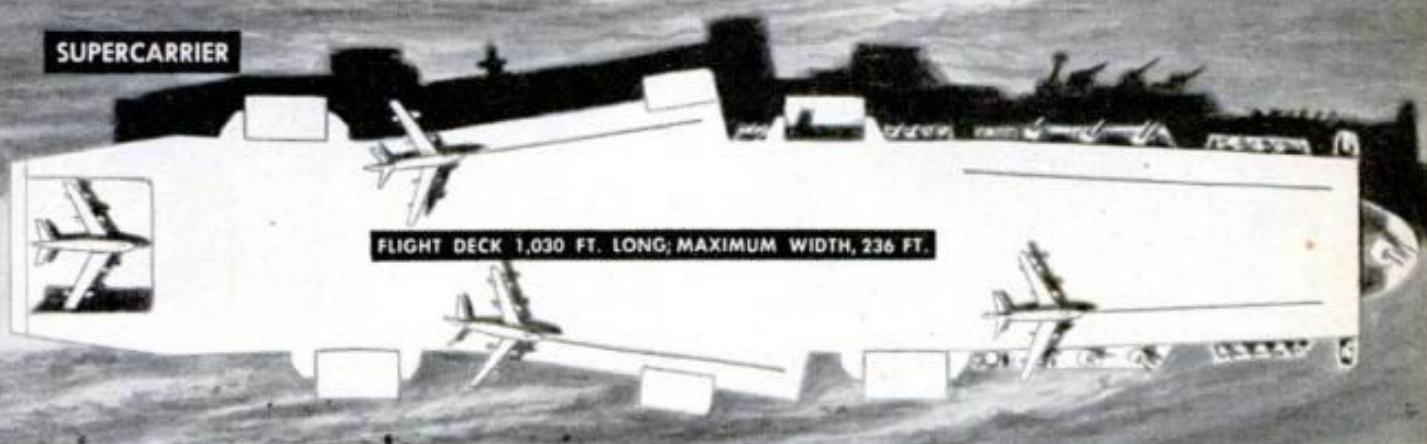
The carrier has been a floating garage, built around a complicated plane engine that takes a lot of elaborate service. When something goes seriously haywire in jets, you'll



ESSEX CLASS



SUPERCARRIER



The Navy's speedy new floating airdrome will more than double the size of carrier airfields.

probably replace the engine with a new one.

The carrier has been just a ship, with a row of stacks on deck, and conventional aircraft have finagled their way around the obstructions as best they could. The plane with the piston engine can keep wiggling into position until it hits the apron. With jets, it's a straighter shot. And a costly waste of fuel, going all the way around the circle again, in case you get a wave-off.

It all adds up to a need for unobstructed space on the flight deck—and a lot more of it. Jets mean new handling and servicing techniques, new equipment, and new procedures all around.

To those who think of the present 45,000-ton *Midway* class as the carrier of the future, the Navy explains that, as jet planes grow in size, range, and speed, even the *Midway* carriers will eventually become obsolete. They represent an outgrowth of wartime experience and the grafting of one enlargement after another upon a hull that

began at only about a third of its present size.

In the first place, the *Midway* has all too little space on the flight deck for the handling of big planes. Her airstrip is only 132 feet at its widest point and only 932 feet in length. Counting the obstruction of the island, only about 100,000 square feet are left in which to trundle planes around.

Compared with this, the flight deck of the new CVA-58 measures 236 feet at the widest point and 1,030 feet in length. This gives more than 200,000 square feet of space in which planes can be moved about freely. In fact, the flight deck of the new carrier will be so huge that an Army-Navy football game could be played at one end while a Rose Bowl game was going on at the other.

And even the armored flight decks of the *Midway* are not strong enough to take the pounding of future airplanes—impacts that are the product of their great weights and speeds. The CVA-58's deck will be stressed

This comparison of the combat ranges of carrier aircraft shows how far the CVA-58 will outreach her predecessors. Able to stay at sea for months, she is expected to cruise 900 miles a day and launch planes with a striking range more than five times that of World War II carrier bombers.

1,700 MILES
PROPOSED JETS
FROM CVA-58

POPULAR SCIENCE

Jan. 1949



25¢

Monthly



Why Navy Wants Supercarriers

PAGE 114

By Rich

There's a strange, secrecy-shrouded contest, short of open hostilities but with deadly serious military implications —

Cold War in Space

By **WILLY LEY**

ILLUSTRATIONS BY **BOB McCALL**

Some time in 1970 a manned space scout is going to creep up to an orbiting satellite. The spacecraft will be of a shape not yet seen in space, resembling a motorboat with displaced rudders, or a flatiron with fins. It will inspect the satellite carefully, at close range. Then its radio operator will transmit to the earth a coded message whose substance may be like this:

"Satellite 1970 PL-2 is evidently a surveillance satellite. Nuclear radiation from it indicates a power reactor, not a warhead."

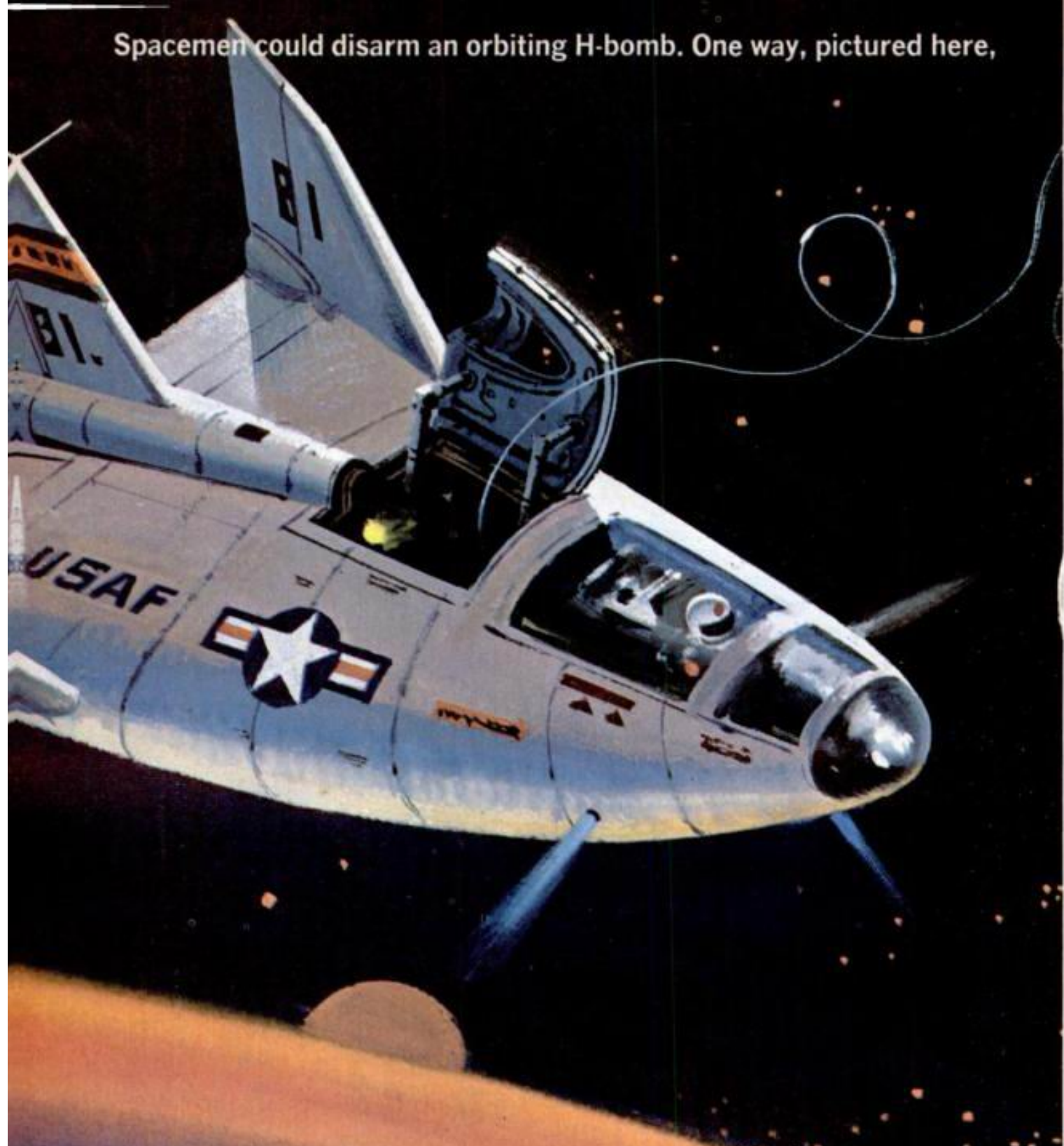
The decoded message may be phrased in English, Russian, or still another language. It would indicate that the alien satellite was no orbital

Continued

If space war waxed hot, conventional weapons could find strange new uses. Hail of bullets from heavy-caliber machine gun, riddling lenses and other equipment of a hostile "spy" satellite, as envisioned in drawing, could put it out of business in a jiffy. Since the explosions of projectiles would inflict little blast damage in airless space, direct hits on spacecraft with something solid—bullets, shell fragments, or homing missiles—might be expected to prove more effective.



Spacemen could disarm an orbiting H-bomb. One way, pictured here,



nuclear bomb — and that there was not yet a “hot” space war.

Interception and examination of suspicious satellites by manned spacecraft may be foreseen in the near future. It will be one of the logical developments of the cold war in space — a strange, secrecy-shrouded contest, short of open hostilities but with deadly serious military implications — that is going on right now.

Hush-hush trials at remote Johnson Island in the mid-Pacific are refining U.S. space-war weapons, already operational, for the mission

Continued

McCall

would sever antenna by which it receives commands from the ground



"The manned space scout will be of a shape not yet seen in

of destroying hostile satellites. They are the American answer to a threat of attack upon us from space, brought into the open last year by a Russian claim to have developed an orbital nuclear bomb. Both East and West have put surveillance satellites (a polite name for spy satellites) in orbit. And both have been conducting studies, at least on paper, bearing on possible tactics and armament for space combat.

Surveillance satellites. The cold-war race to explore potential military uses of space began with "spy" satellites.

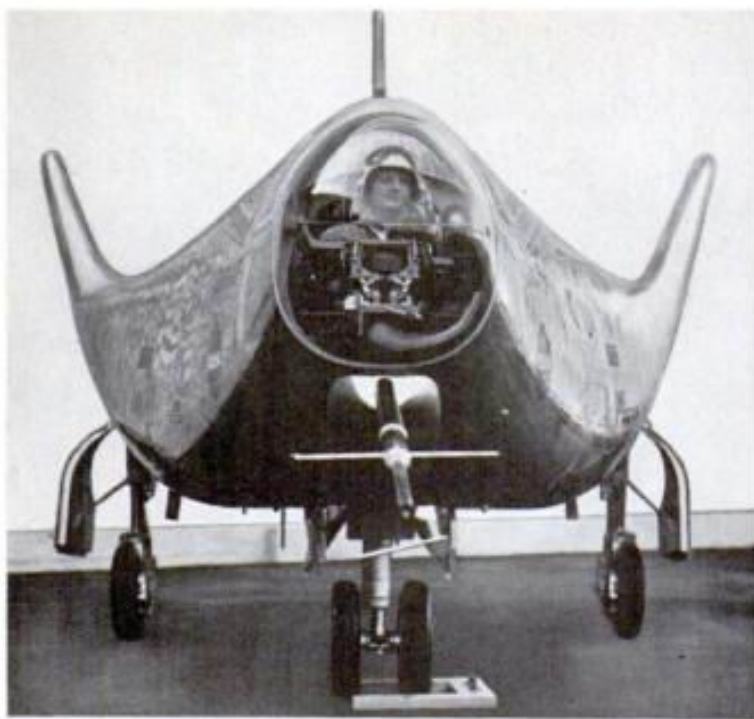
The first one we know about, orbited in 1960, was the U.S. Midas II. This and two more Midas satellites in 1961 were openly called prototypes of craft to give early warning of an enemy ICBM attack, by detecting the heat of large missiles' rocket blast at takeoff. Then U.S. military-satellite programs went under wraps—and further launchings, if announced at all, have generally been unidentified by type. The Midas satellites—which now have a competitor in long-range radar early-warning systems—reportedly are still in the research-and-development stage.

Photo satellites with telescopic cameras of fantastic power now gather military intelligence. Samos II, launched in 1961, was the only known U.S. example before the secrecy blackout—but was a prototype of a series that has since been reported operational. Current Samos craft are believed to be recovered with their films, although this kind of space news does not get into the papers. Their pictures may be proving highly effective for reconnaissance.

For example, a step-up in the power of Russian rocket boosters about two years ago was indicated by the increased size and strength of Soviet rocket-test stands. How this news reached us has not been revealed, but speculation credits it to Samos photos.

Since two can play at that game, and do, quite possibly you may be in a photograph snapped today by an unseen Red satellite. Former Premier Khrushchev, in a moment of unusual candor, told an American official two years ago that the Russians were using photo "spy" satellites, too—and jestingly offered to swap photos with us.

Satellite trackers here have no doubt that the Red sky spies are among the varied unmanned craft that the Russians call Cos-



Wingless HL-10 craft, head-on, looks like this.

mos satellites. Beginning with Cosmos 4 in 1962, many of these have been brought down and recovered on land after a few days in orbit, apparently by the same parachute-recovery technique that Russian manned spacecraft use. Cosmos 45, 65, and 92 were weather-photo satellites that brought down their films for development, the Russians themselves say. More than 40 other recovered Cosmos satellites could as well have brought back spy films. Probably many did.

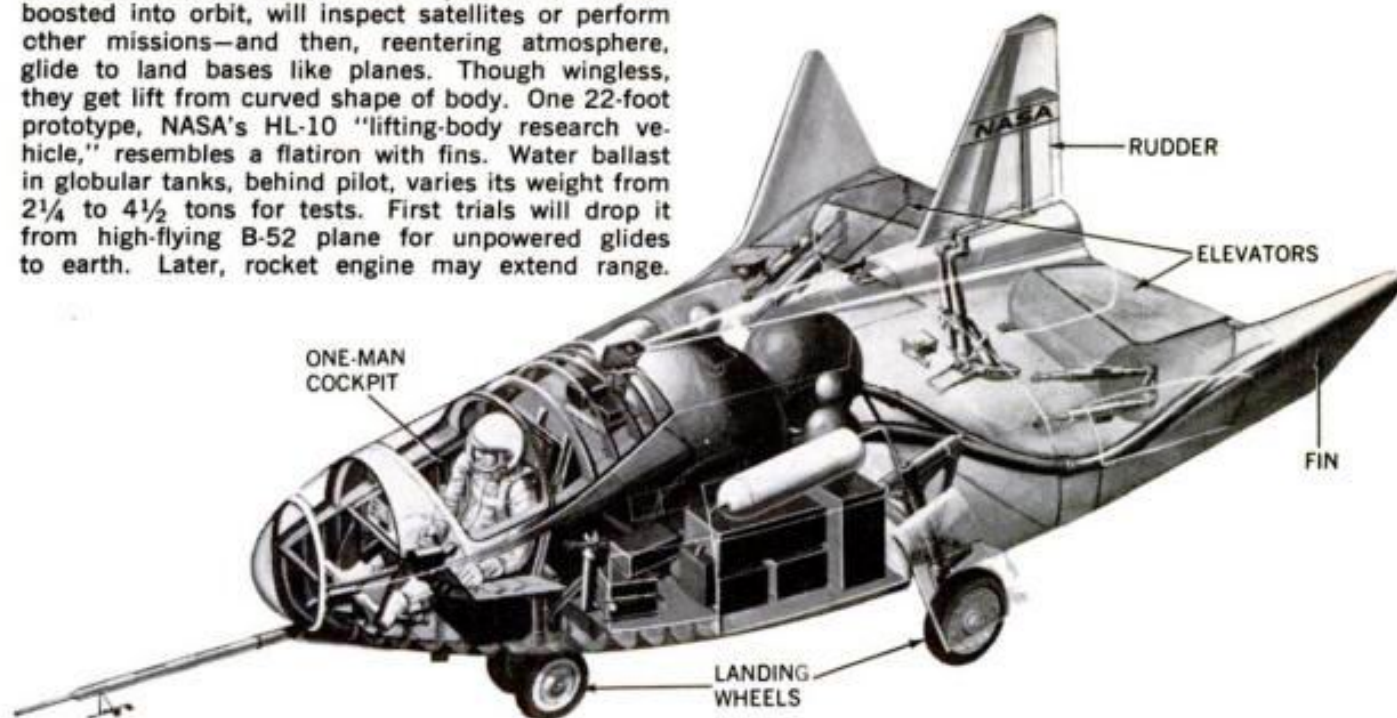
If the Reds' eyeing of us eases world tension, by convincing them we are not secretly preparing to attack them, perhaps we have more to gain than lose by it. Actually the East-West photo satellites are putting into practice, in modified form, the "open skies" plan for aerial inspection that President Eisenhower proposed and the Russians rejected some years ago.

Surveillance spacecraft of another sort—this country's Vela satellites—are designed to detect any clandestine atomic explosions in space, in violation of the existing nuclear test-ban treaty. Since the treaty went into effect, in 1963, we have orbited six of them. No Russian spacecraft with the far-ranging orbits suited to this purpose have yet appeared in the heavens.

Orbiting H-bombs? What would concern

space"—but already foreshadowed by trial craft like this one

New generation of manned spacecraft, rocket-boosted into orbit, will inspect satellites or perform other missions—and then, reentering atmosphere, glide to land bases like planes. Though wingless, they get lift from curved shape of body. One 22-foot prototype, NASA's HL-10 "lifting-body research vehicle," resembles a flatiron with fins. Water ballast in globular tanks, behind pilot, varies its weight from 2¼ to 4½ tons for tests. First trials will drop it from high-flying B-52 plane for unpowered glides to earth. Later, rocket engine may extend range.



Cutaway shows HL-10 design for early gliding trials. Rocket engine may be added later.

us more than Red spy satellites was illustrated last November when Tass, the official Soviet news agency, made a startling announcement. Russia, it claimed, now had "orbital missiles" whose warheads could deliver a surprise blow "on the first or any other orbit around the earth." Of course this may have been said to comfort the Russian people, or discomfort the Chinese leaders. Or it could be true.

The possibility of orbiting nuclear warheads—which could be "called down" upon ground targets by radio command at any time—has long been recognized. Since both the U.S. and Russia had agreed not to, in a United Nations resolution, the Tass report raised eyebrows in Washington satellite-high. Queried about it by our State Department, Russia denied it had orbited any armed satellites or planned to—but the UN agreement, it maintained, was no ban on *developing* them. To Western observers it looked prudent, if such missiles really existed anywhere, not to rely solely on their possessor's assurance of good intentions.

Now, it is true that many weapons experts question the military value of orbiting H-bombs, and the U.S. has studied and rejected them. Compared to ICBMs launched from silos, they have been called less accurate, more limited in size and

power, and far more difficult to control reliably. Nevertheless we would hardly care to have them whizzing over our heads—and the U.S. now has counterweapons developed primarily to meet just that threat:

Antisatellite weapons. Ready for action are two U.S. weapon systems for destroying armed satellites. One, based on the Nike-Zeus anti-ICBM missile, successfully intercepted a satellite as early as 1963. The other, using the Thor-Agena rocket combination, duplicated the feat early in 1964. Since then, these weapons have repeatedly scored satellite intercepts at altitudes up to hundreds of miles, Secretary of Defense Robert S. McNamara has disclosed. Practically all further details, including the kind of warheads used for the "kill," remain classified. Some of our secret military satellites launched during recent years could have been targets for the trials.

An order to fire the antisatellite weapons would be transmitted from Continental Air Defense Command, the U.S. portion of NORAD, whose combat operations center is carved in the granite heart of Cheyenne Mountain, Colo. [PS, Nov. '65]. Within this underground fortress, into which pour more than 10,000 satellite observations

[\[Continued on page 170\]](#)

The Microwaves Are

**Invisible network will handle phone calls, telegrams, television,
FM and AM broadcasts, complete newspapers—even carry your mail.**

By Martin Mann

PSM photos by Robert F. Smith

COMMUNICATIONS are being revolutionized faster than you think. The humming wires beside the highways already are rivaled by new systems, capable of transmitting more spoken or written words and more still or moving pictures from coast to coast. The difference between these new systems and those of the past is as great as that between oxcarts and stratoliners. Radio relay systems, coaxial cables, and other improvements in communications systems soon will bring you not only better, faster services such as you already know, but also completely new kinds of service.

Your radio program now comes to you in waves a fifth of a mile long. Your son's television program, and his telegrams and long-distance phone calls—even his mail—will come to him in waves only two or three inches long. Telegrams are now flying between New York and Philadelphia in these microwaves; phone calls will be made in microwaves next year between New York and Boston; and television shows are being sent this way now from New York to Schenectady and Philadelphia.

These microwave relays use invisible beams in the air instead of wires. No poles support them. The poles and wires are replaced by steel or concrete towers every 30 miles or so. On these towers are antennas that catch the microwaves, shunt them down to repeater equipment to be amplified, then send them on to the next station.

These relay stations are as automatic as

electric refrigerators—designed to operate with only occasional human supervision. If a tube fails, its duplicate is standing by, ready to switch into operation immediately without interrupting service—and at the same time to flash a trouble signal to the nearest testboard. A furnace heats each tower building in winter and in the summer it is cooled by air-conditioning devices for the machinery's benefit. Banks of batteries and current from the local utility companies supply the power. In some stations, a gasoline generator automatically starts itself and takes over the job of charging the batteries if the utility lines fail.

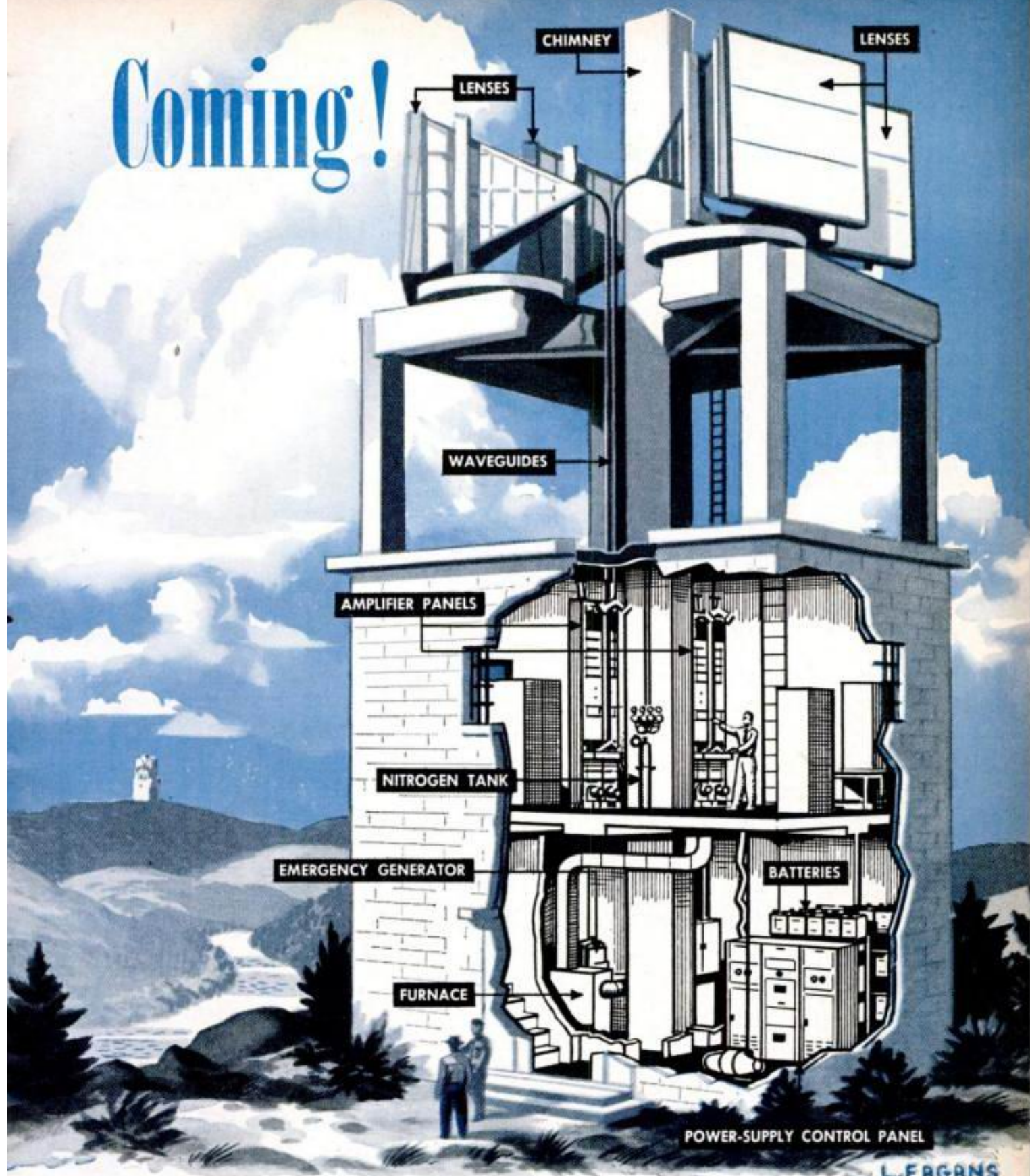
You will not notice any difference when your phone calls begin to go through these radio relays. On a call from New York to Boston, for example, your voice will travel as usual from the handset through the switchboard into a trunk line for Boston. That trunk line now is a thick copper, rubber, and lead cable buried in a ditch along the Atlantic coastline. When radio relay is used, however, the cable carrying your voice will end on the roof of the telephone building in lower Manhattan. There it will feed into a microwave transmitter, aimed at the first relay station atop Jackie Jones Mountain, N. Y., 35 miles away.

At Jackie Jones, a strange antenna that looks like a big square metal funnel will receive the beam. This antenna is a set of criss-crossing metal plates that focus microwaves into a narrow beam. From this lens, the beam will travel down into the tower to amplifiers, to be strengthened after its 35-mile trip. It will then go back up to a



Seven automatic towers will relay microwave beams from New York to Boston in a

Coming!



L. FAGANS



telephone system, soon to begin operation. Large picture shows layout of one tower.

NOVEMBER 1947 95





Real Planes Add Up to a Dream

DON'T let this odd contraption fool you. It's artist-flier John T. McCoy, Jr.'s idea of how a giant air liner the size of the B-36 might look. Despite its unconventional design, its features have all seen actual use in past or present aircraft.

The huge plane's canard, or "tail first," design places the passengers ahead of engine noise and fire hazards, and provides a

forward view unobstructed by a large wing. The bicycle landing gear saves weight, permits a thinner wing and helps eliminate gear failure, since the wheels retract into the fuselage and can be checked in flight.

Ex-Major McCoy, who has been flying airplanes since 1926 and drawing pictures of them even longer, has full confidence in the flying ability of his creation.



1 The retractable nose glass is borrowed from Republic's Rainbow. It uncovers conventional-type, flat windshield for undistorted vision during landings and take-offs.



2 Canard placement of wings harks back to the early efforts of the Wright brothers. It was used more recently on such experimental planes as the Curtiss XP-55 Ascender.



3 The bicycle landing gear, another old-timer, turns up again on the new Martin XB-48, as shown above. McCoy's use of it also includes the small outboard balance wheels.

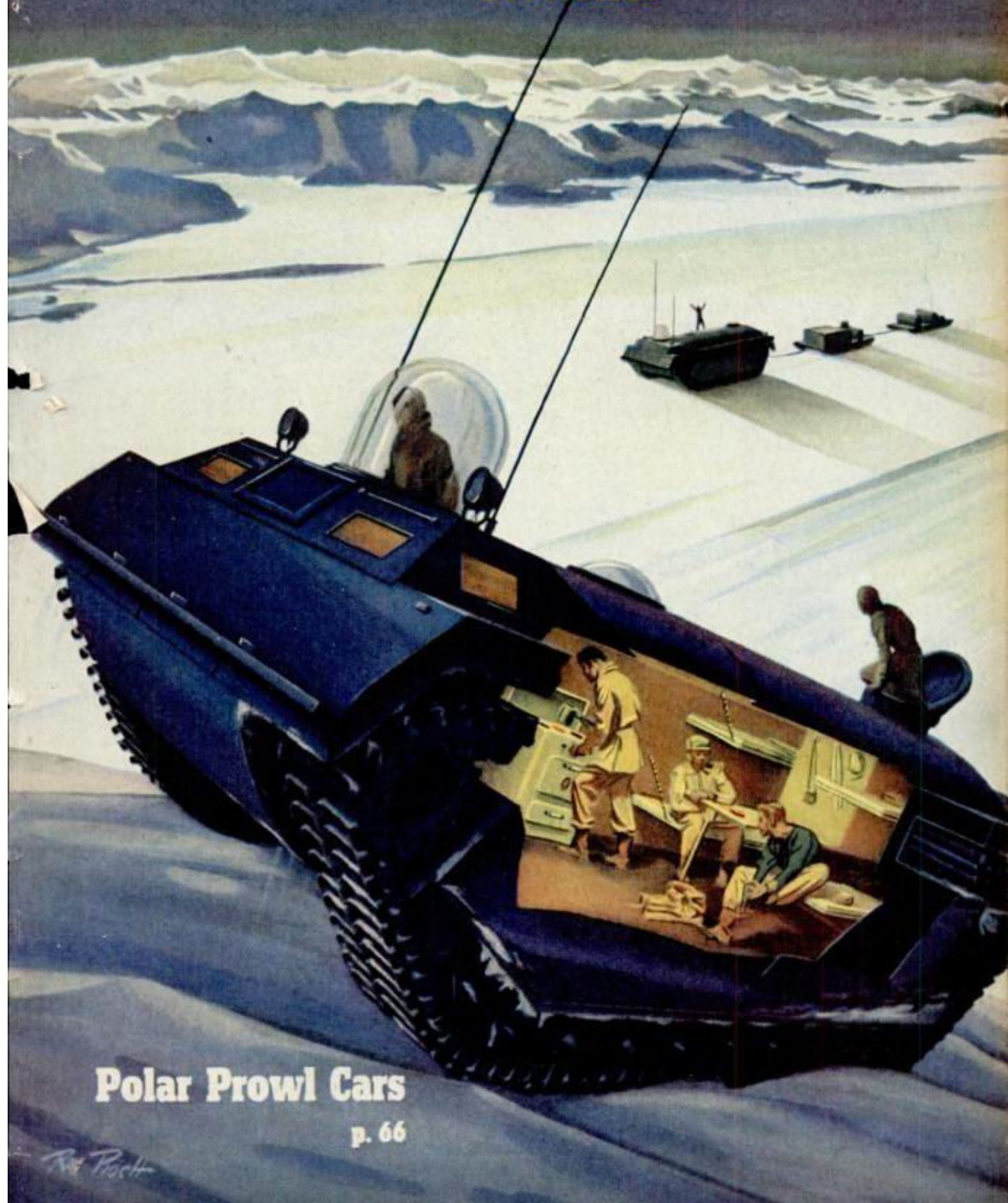


4 Pusher-type tail props of the Langley are combined with wing-mounted jet engines as on this Douglas Mixmaster. The counter-rotating props reverse for braking and backing.

POPULAR SCIENCE

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MONTHLY



Polar Prowl Cars

p. 66

Art Borth

Mechanize Arctic Living

Photos by Fred Sparks and U.S. Navy. Drawings by Phil Santry



TO THE regret of all Jack London fans, the dog sled as the sole means of polar travel is a thing of the past. Its limited load and slow speed are all right for a small exploring party but rule it out for hauling the ponderous tackle needed for permanent stations, mining or oil developments—or a modern army.

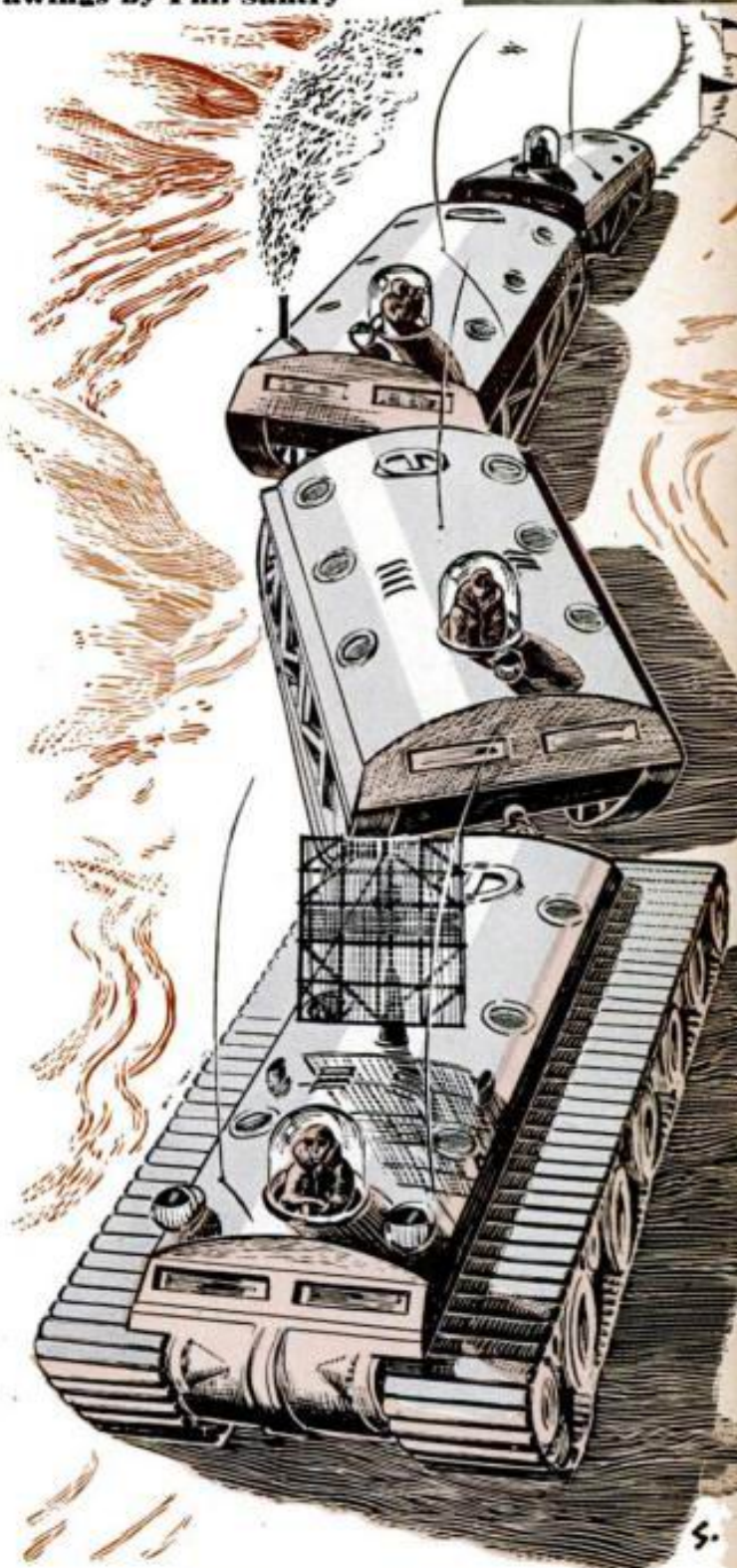
At Little America, tracked vehicles designed for amphibious operations proved almost as good at crossing icy terrain as they were at landing on palm-fringed islands. And the weasel turned out to be an excellent polar jeep where true jeeps were useless.

But for regular polar travel over land a new vehicle, to be designed along the lines of the Marine Corps LVT-4, an alligator tractor, will prove invaluable. Captain Vernon Boyd led two LVTs in a cross-country trek, hauling giant sleds loaded with supplies. Now he is working with the Navy's Bureau of Ships on a machine that may well become the polar "locomotive."

"Snowshoes" for Tractors

As shown at right, proposed special features include a bubble turret to protect a driver while enabling him to sit high enough to see crevasses lurking ahead. One thing any caterpillar vehicle for polar use requires is "snowshoes"—steel additions to the treads making them wide enough to distribute the weight. Otherwise they sink in soft ice.

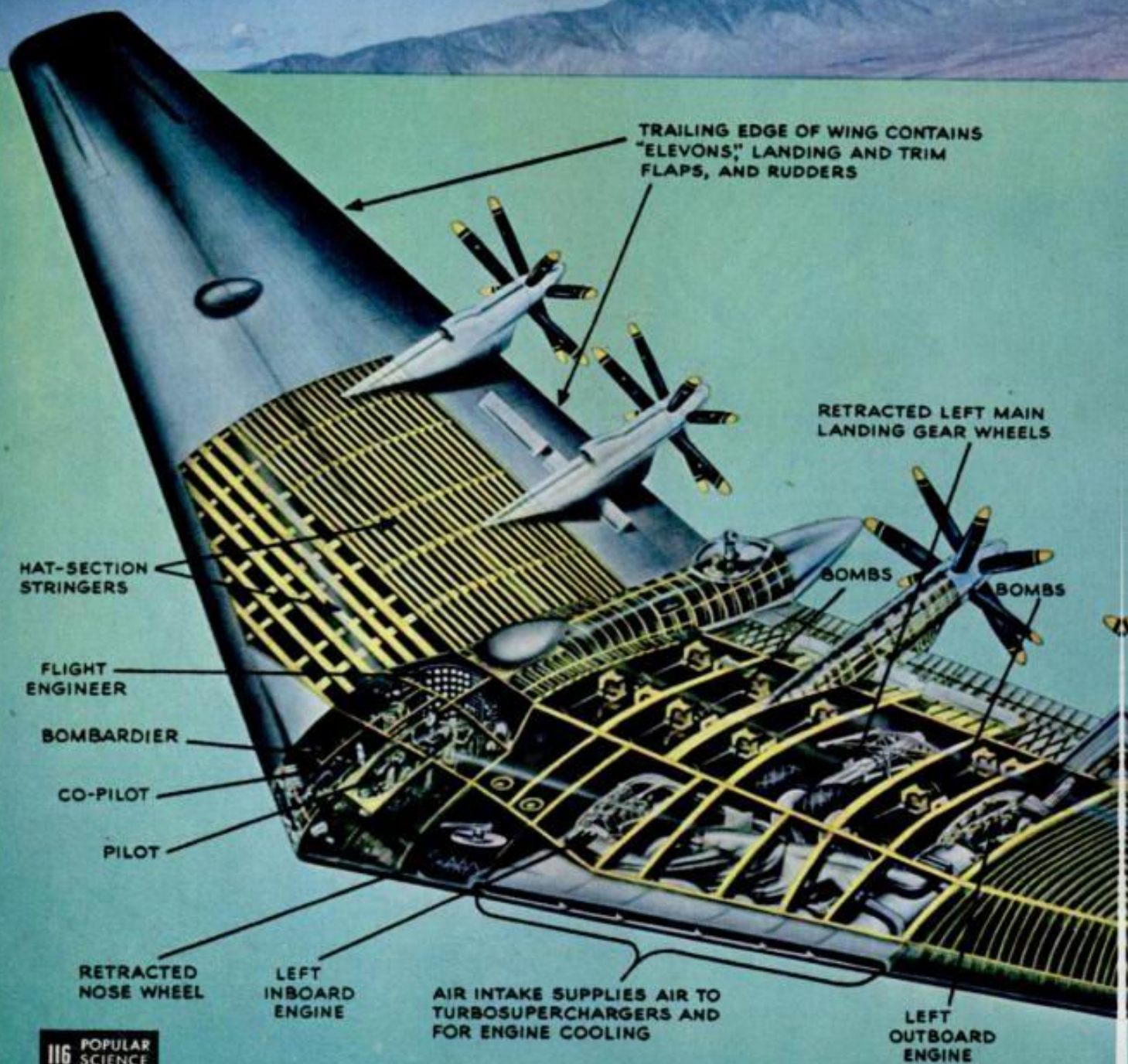
The Navy has already experimented with snow trains in northern Alaska. There the Construction Corps has used them to supply its remote Naval Petroleum Reserve. They have gone 300 miles without support, hauling hundreds of tons of equipment. Men slept and cooked meals on sled-mounted cabins hauled by the trains, and put on weight doing it. Speeds averaged five m.p.h. Much information about different types of tractors and equipment has been gained in the last three years—and will pay off at the poles.



Polar tractor of the future pulls streamlined personnel-carriers. Third vehicle spews aluminum foil to permit radar tracking of party. Automatic device on last sledge drops trail flags.

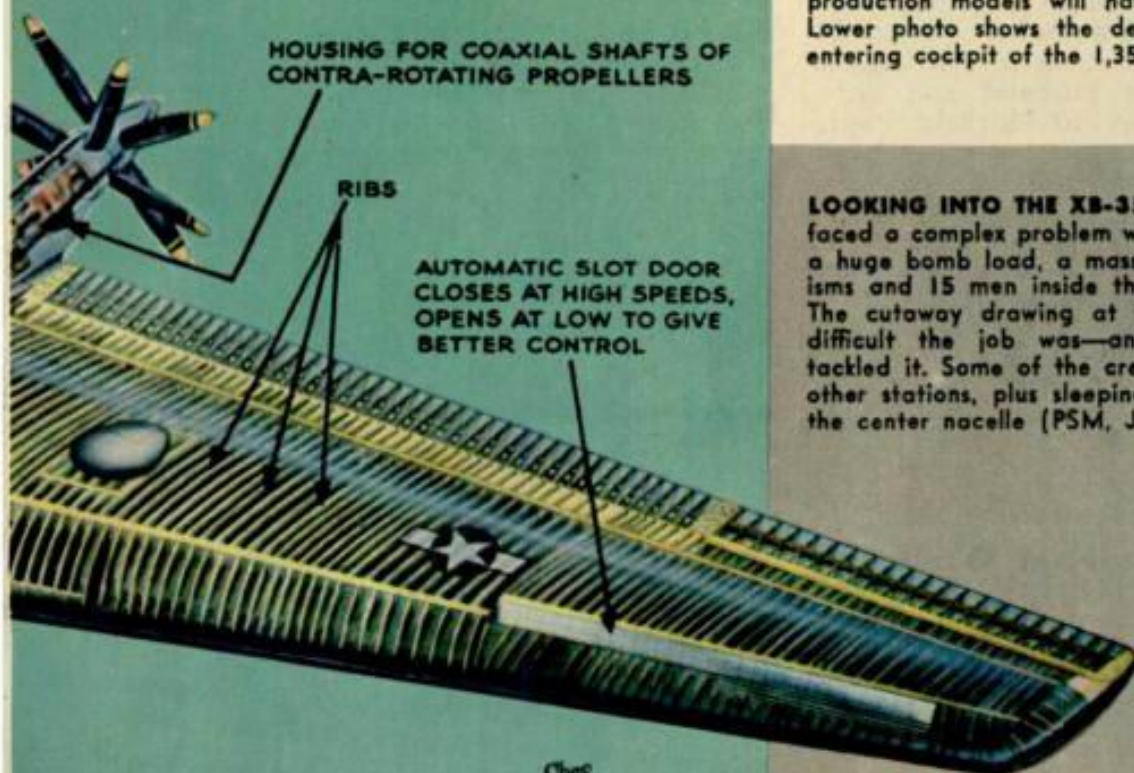


TINY TIM TAKES OFF. High above the vast Naval Ordnance Test Station at Inyokern, Calif., this Corsair fighter is being left behind by one of its 12-inch Tiny Tim rockets, fired a moment before.

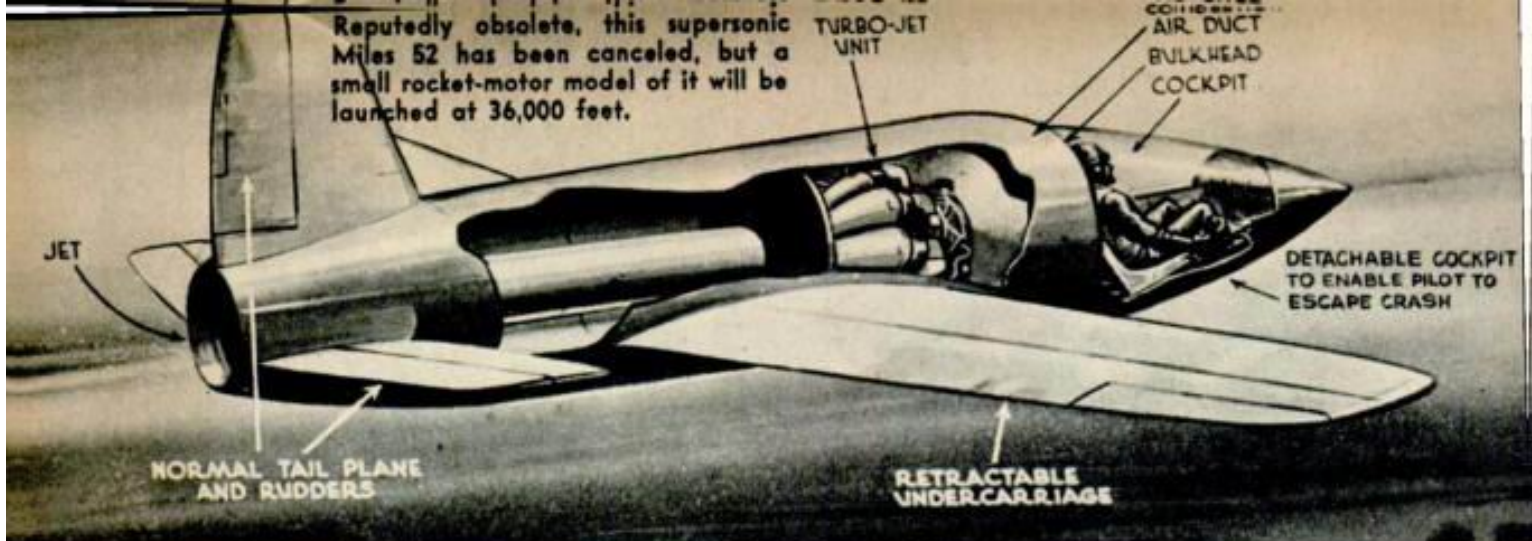




VJ-21 MAKES ITS BOW. With a 75-hp. engine atop its wing, the Volmer Aircraft Company's new three-place personal plane has a cruising speed of 110 m.p.h. and a 500-mile range. Prototype has a single main wheel and small retractable wing wheels (one of which is visible in top photo), but production models will have fixed tricycle gear. Lower photo shows the designer, Volmer Jensen, entering cockpit of the 1,350-pound craft.



LOOKING INTO THE XB-35. Northrop's engineers faced a complex problem when it came to stowing a huge bomb load, a mass of operating mechanisms and 15 men inside the Army's Flying Wing. The cutaway drawing at the left indicates how difficult the job was—and how the engineers tackled it. Some of the crew positions are shown; other stations, plus sleeping quarters, are also in the center nacelle (PSM, Jan. '47, p. 95).



Britain Goes Supersonic

Engineers race to design first plane to fly faster than sound.

B RITISH engineers are making an all-out attempt to build aircraft that fly faster than the speed of sound. To do it they are concentrating on developing gas turbines, jet propulsion and rocket engines.

British airplanes have broken existing world speed records in recent months. Now British experts are developing engines and planes to set fresh marks. Hint of what they are like is given by the canceled Miles 52, apparently obsolete even before completion. The M-52's 17,000-hp. three-stage power plant almost filled the fuselage. Ex-

haust from a jet engine with centrifugal blower ran a gas turbine. This brought more air into the stream and pushed it into a duct. Here more fuel was burned to give an extra push. The plane was expected to hit 1,000 m.p.h., 250 m.p.h. faster than sound. The ones under wraps presumably are planned to do even better.

The solution of supersonic difficulties is complicated by the fact that ordinary wind tunnels cannot be used for testing. Air bounding off the sides sets up disrupting currents, and a shock wave "chokes" the tunnel. For this reason British engineers are using various types of pilotless models, some dropped from high altitudes, some depending on rockets.

THE "FLYING DUCK" TYPE
AN AIRCRAFT DESIGNED TO FLY FASTER THAN THE SPEED OF SOUND, HAVING REAR WINGS WITH LARGER SPAN THAN CHORD (I.E. HAVING LARGE ASPECT RATIO)

Various designs proposed for supersonic aircraft. The swept-back wings and delta designs are intended to cut drag but offer control difficulties if used at low speeds.

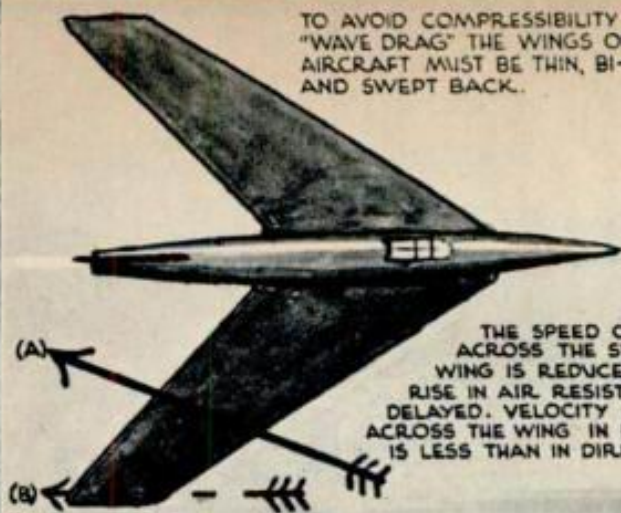
SHARP-POINTED FUSELAGE

FRONT WINGS WITH ONLY SHORT SPAN AND LARGE CHORD (LOW ASPECT RATIO)

POSSIBLY THE TWO WINGS MAY BE CONVENIENTLY COMBINED INTO THIS TRIANGULAR "DELTA" DESIGN

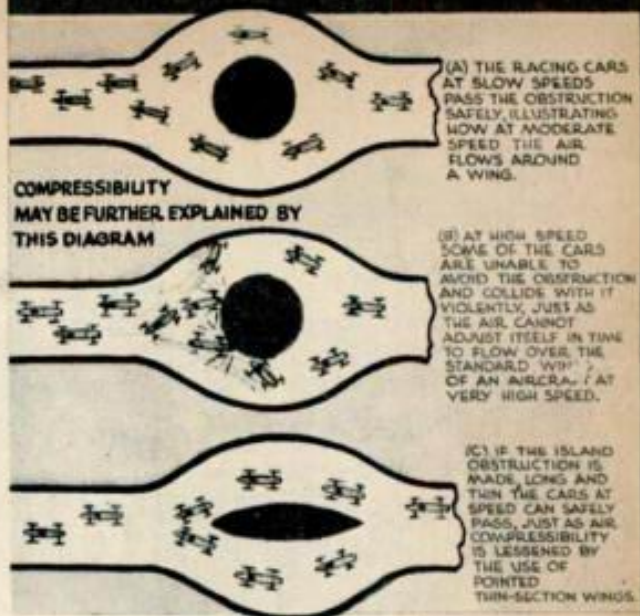
A GERMAN "DELTA" PROJECT BY DR. LIPPICH

TO AVOID COMPRESSIBILITY AND REDUCE "WAVE DRAG" THE WINGS OF SUPER-SONIC AIRCRAFT MUST BE THIN, BI-CONVEX AND SWEEP BACK.



THE SPEED OF AIR-FLOW ACROSS THE SWEEP-BACK WING IS REDUCED AND THE RISE IN AIR RESISTANCE DELAYED. VELOCITY OF AIR ACROSS THE WING IN DIRECTION (A) IS LESS THAN IN DIRECTION (B)

COMPRESSIBILITY MAY BE FURTHER EXPLAINED BY THIS DIAGRAM



SUPER-SONIC

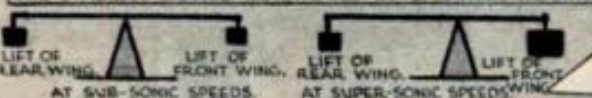
SUB-SONIC

AT SUB-SONIC SPEEDS THE LIFT OF A WING IS AT A POINT IN BACK FROM LEADING EDGE.

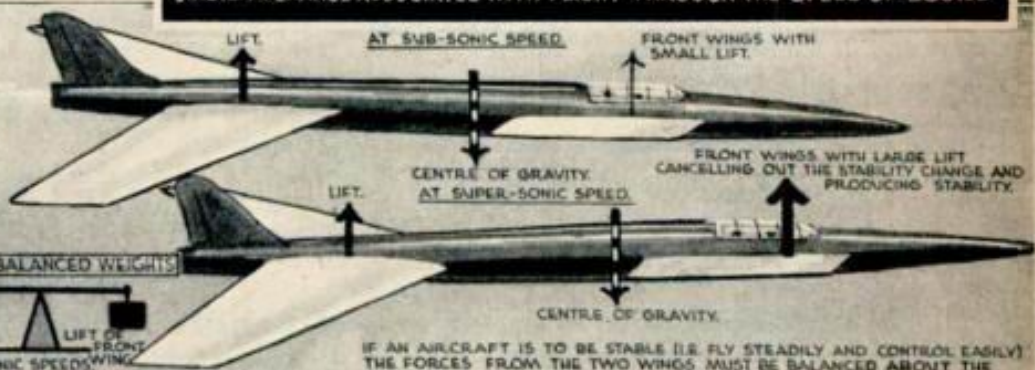
AT SUPER-SONIC SPEED THE STABILITY CHANGE OCCURS AND THE LIFT MOVES REARWARD TO 1/2 WAY BACK.



THE STABILITY CHANGE ILLUSTRATED BY BALANCED WEIGHTS

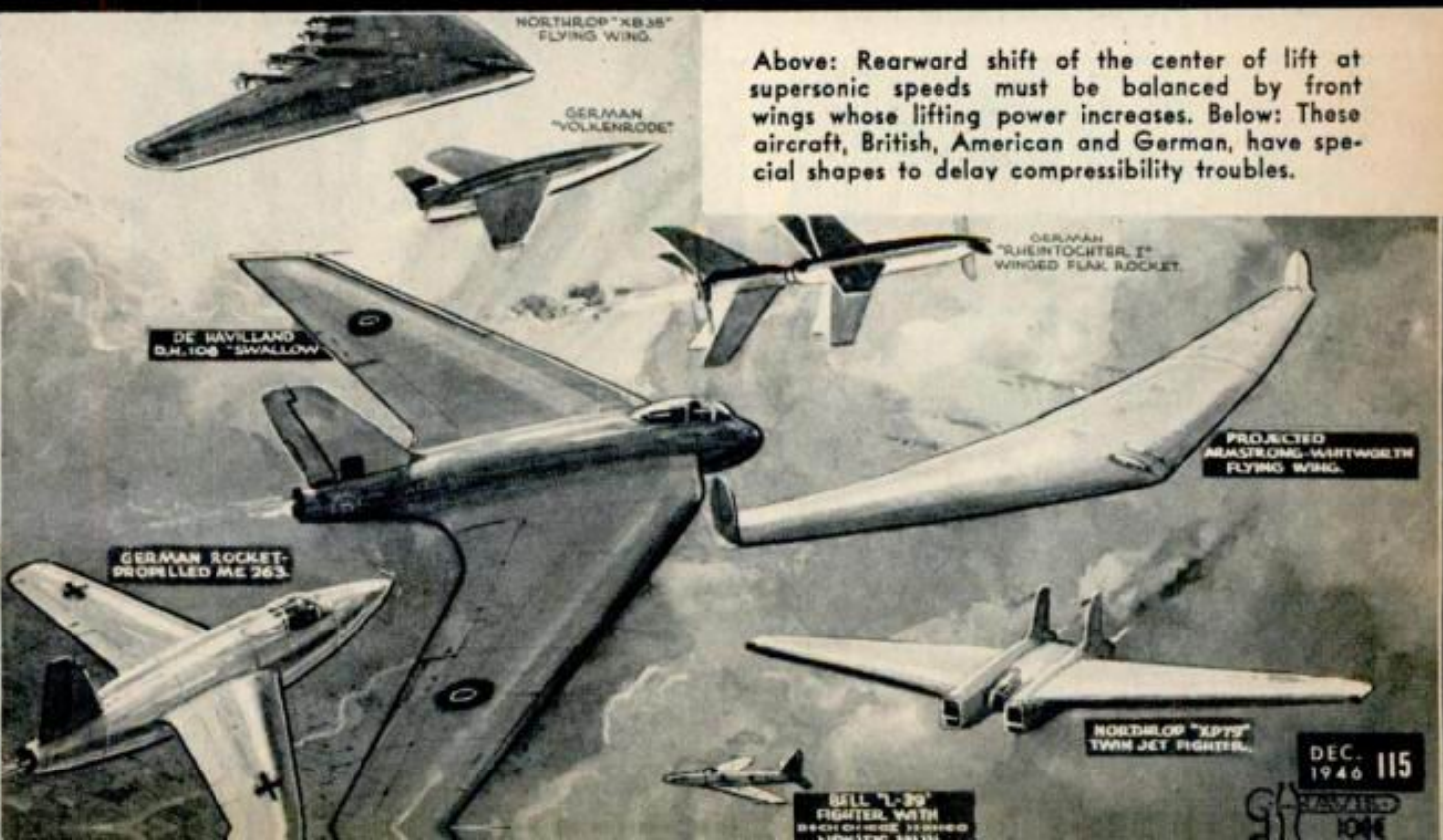


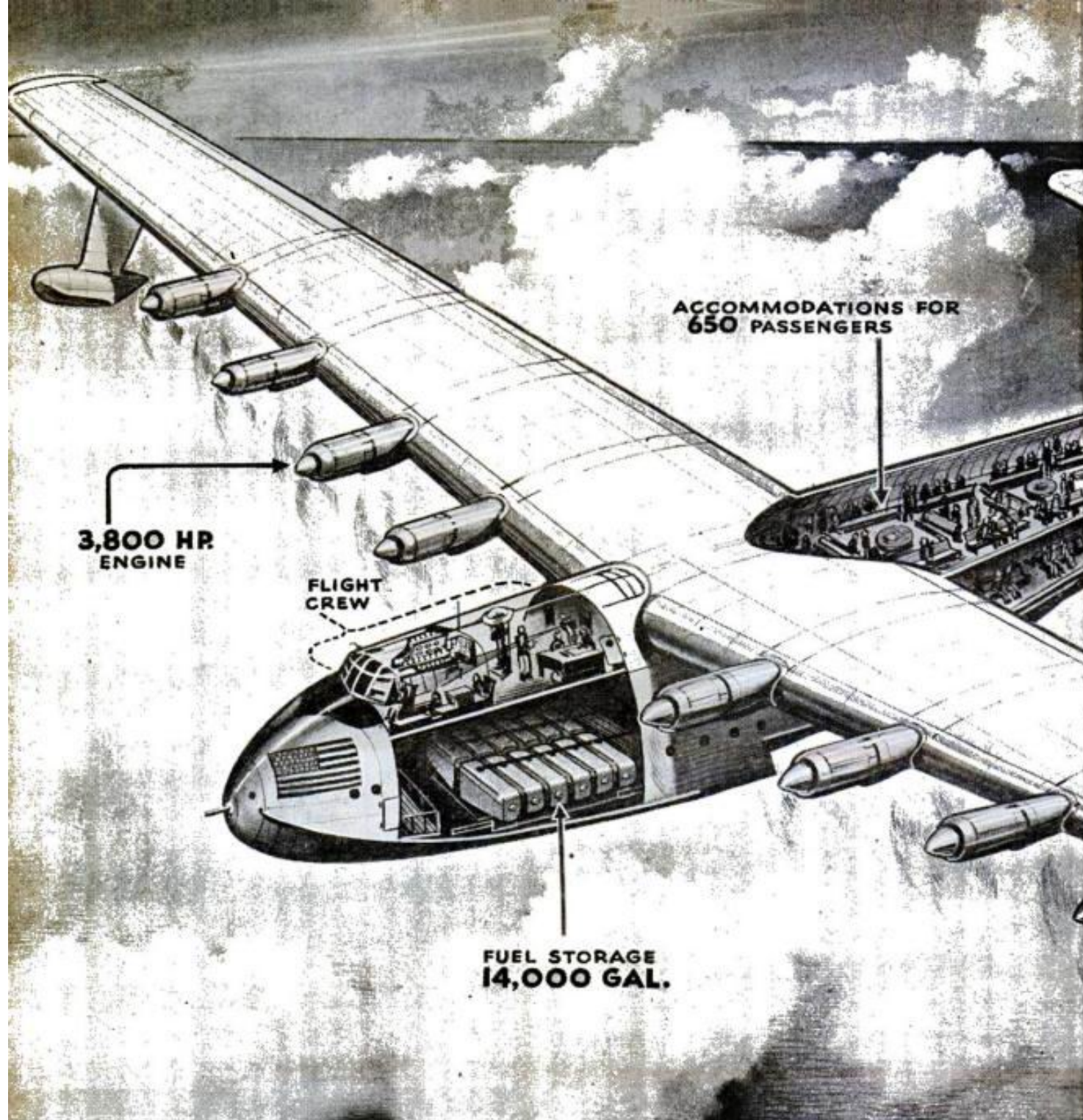
"STABILITY CHANGE" ASSOCIATED WITH FLIGHT THROUGH THE SPEED OF SOUND



IF AN AIRCRAFT IS TO BE STABLE (I.E. FLY STEADILY AND CONTROL EASILY) THE FORCES FROM THE TWO WINGS MUST BE BALANCED ABOUT THE CENTRE OF GRAVITY OF THE AEROPLANE.

Above: Rearward shift of the center of lift at supersonic speeds must be balanced by front wings whose lifting power increases. Below: These aircraft, British, American and German, have special shapes to delay compressibility troubles.





This cutaway drawing of Howard Hughes' H-4 shows the vast interior that could hold a payload of 60 tons.

Looking Inside the

Howard Hughes' all-plywood flying boat, with eight 3,000-hp. engines, will fly 3,500 miles fully loaded.

Drawings by ERIC SLOANE

UNDER secret construction for almost three years, the world's biggest airplane has just been revealed in all its giant proportions. It's the \$20,000,000 mystery ship on which Howard Hughes has been working, with Henry Kaiser as a partner until a while back, and is now called merely the H-4.

We thought the Superfortress a pretty fair ship for size, with its 141-foot wing



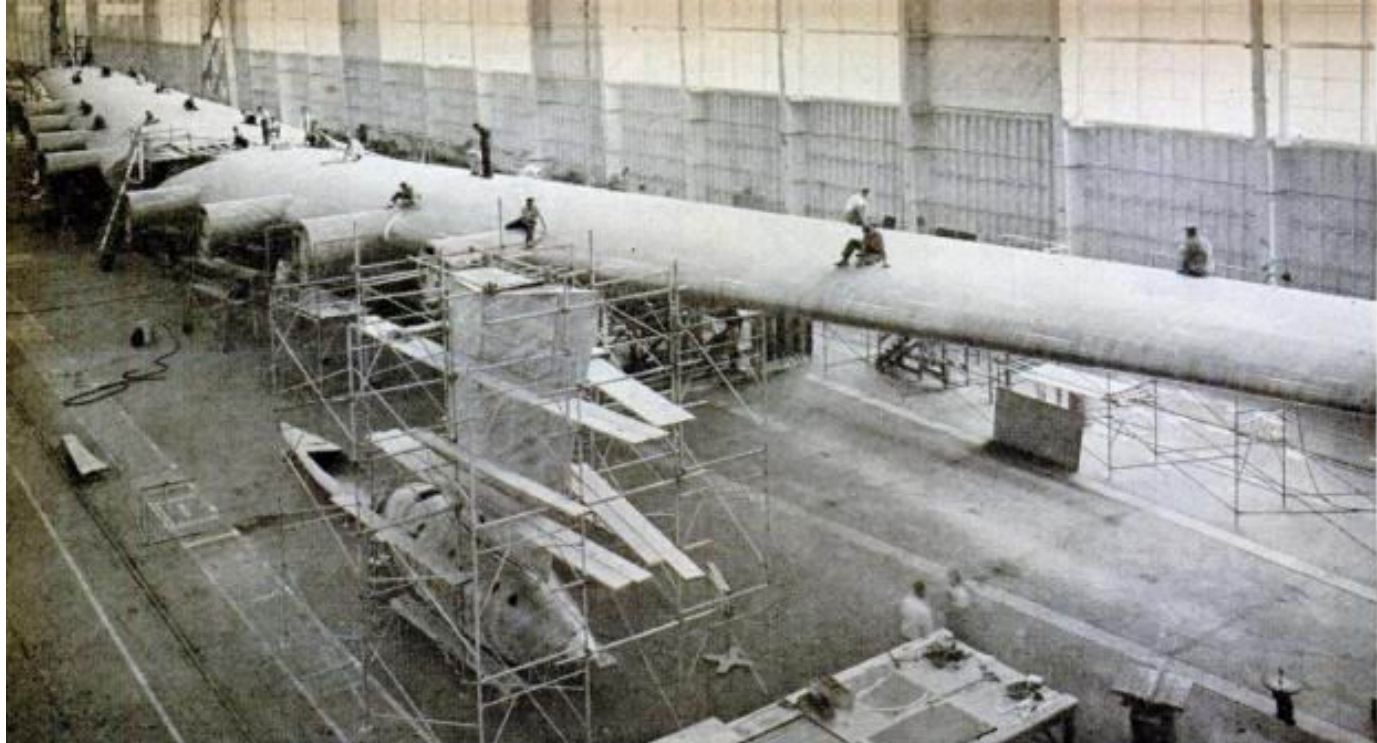
The giant could be a cargo carrier, transport, or hospital ship, and fly nonstop from Honolulu to Tokyo.

World's Largest Plane

span. But the H-4 is big enough to accommodate a Superfort on each wing with room to spare. It has eight engines with a total horsepower of at least 24,000.

The giant's wingspread is 320 feet—longer than a football field. Its hull—it's a flying boat—is 220 feet long and about three stories high. Gross weight will be 400,000 pounds, or 200 tons.

It will be able to carry 650 passengers, with plenty of baggage, across the Atlantic nonstop, or across the Pacific with one stop. Or it can carry a 60-ton Sherman tank, or two medium tanks, or three light tanks. It could take 400 soldiers with five tons of ammunition and equipment across the ocean and bring back 350 wounded with 40 or 50 nurses and doctors. *(Continued)*



WING SPAN is longer than a football field, and thickness at the hull is 13 feet. In this factory scene, expert cabinetmakers have the wing almost finished. One of the H-4's two pontons also is shown.

The H-4 is the fruit of much dreaming and planning by Howard Hughes and Henry Kaiser, followed by a remarkable construction job now nearing completion at Culver City, Calif. They got together in 1942 on the plans for this ship, and started work on it late that year.

The plane is almost entirely constructed of wood strips, glued together. The metal in it, aside from the engines, is negligible. Skin and structural parts are built up of birch and spruce, layer on layer, formed into durable units by modern techniques and the use of new waterproof glues. Thinnest parts of the H-4 are $\frac{3}{64}$ of an inch, built up of three $\frac{1}{64}$ -inch veneers. The thickest part is ten inches, built of 200 veneers $\frac{1}{20}$ of an inch thick. The workers are mostly skilled cabinet-

makers, who know their wood and their glue.

Construction of wings and hull is virtually complete now. The next big job is to move them 22 miles to San Pedro Harbor, where a special graving dock and hangar are being

constructed at a cost of \$203,000. The moving job entails the removal of some 30 power lines and two buildings along the route.

The first flight of the big ship will take place some months hence. When Howard Hughes takes the controls for this flight, he will be sitting 24 feet above the water. The H-4 is not a speedy plane. Its climbing rate is 675 feet per minute, cruising speed 145 miles, ceiling 17,000 feet. Its tanks will hold 14,000 gallons of gasoline. It requires a run of 5,600 feet to obtain a speed of 86 m.p.h. for the take-off, and this takes 67 seconds.

EACH PONTON is taller than a man. Mounted on two such floats and the high, deep struts, the wings would clear a two-story building with room to spare.



Your Pin-Up

GRUMMAN F7F TIGERCAT NAVY FIGHTER. With twice the power of the famous Hellcat and 50 percent more weight, this twin-engine ship is described as the most powerful fighter-bomber yet produced for the Navy. First Navy fighter to have twin engines, it is powered by two 2,100-hp. Pratt & Whitney Double Wasps that put it in the 425-m.p.h. class and give it a mile-a-minute climb. It can carry two tons of bombs, a full-size marine torpedo, or any desired combination of rockets and bombs. With heavier firepower than either the Hellcat or the Corsair, it can smash even a bomber with a single burst. A two-place model is being made for night fighting. First production goes to the Marines; later, Tigercats will fly from our 45,000-ton carriers of the new Midway class.

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Popular Science

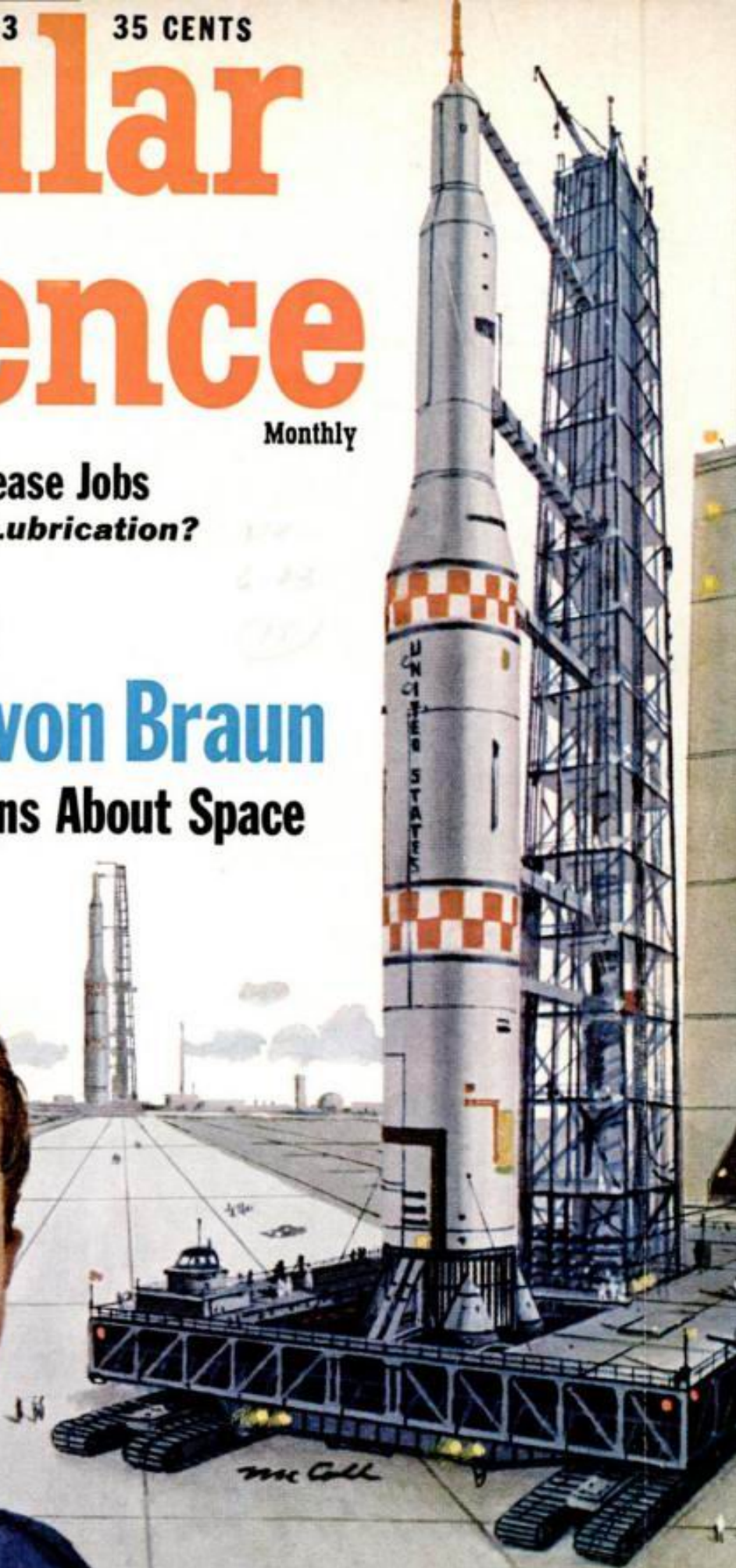
Monthly

30,000 Miles Between Grease Jobs
—How Safe Is Extended Lubrication?

Starting This Month:

Dr. Wernher von Braun

Answers Your Questions About Space



Coast-to-Coast Driving Report
on Dodge's New Motor Home

Moon Rocket Rides Monster Crawler

Giant spacecraft on the way, outgrowing today's launching system, will use this radical new one

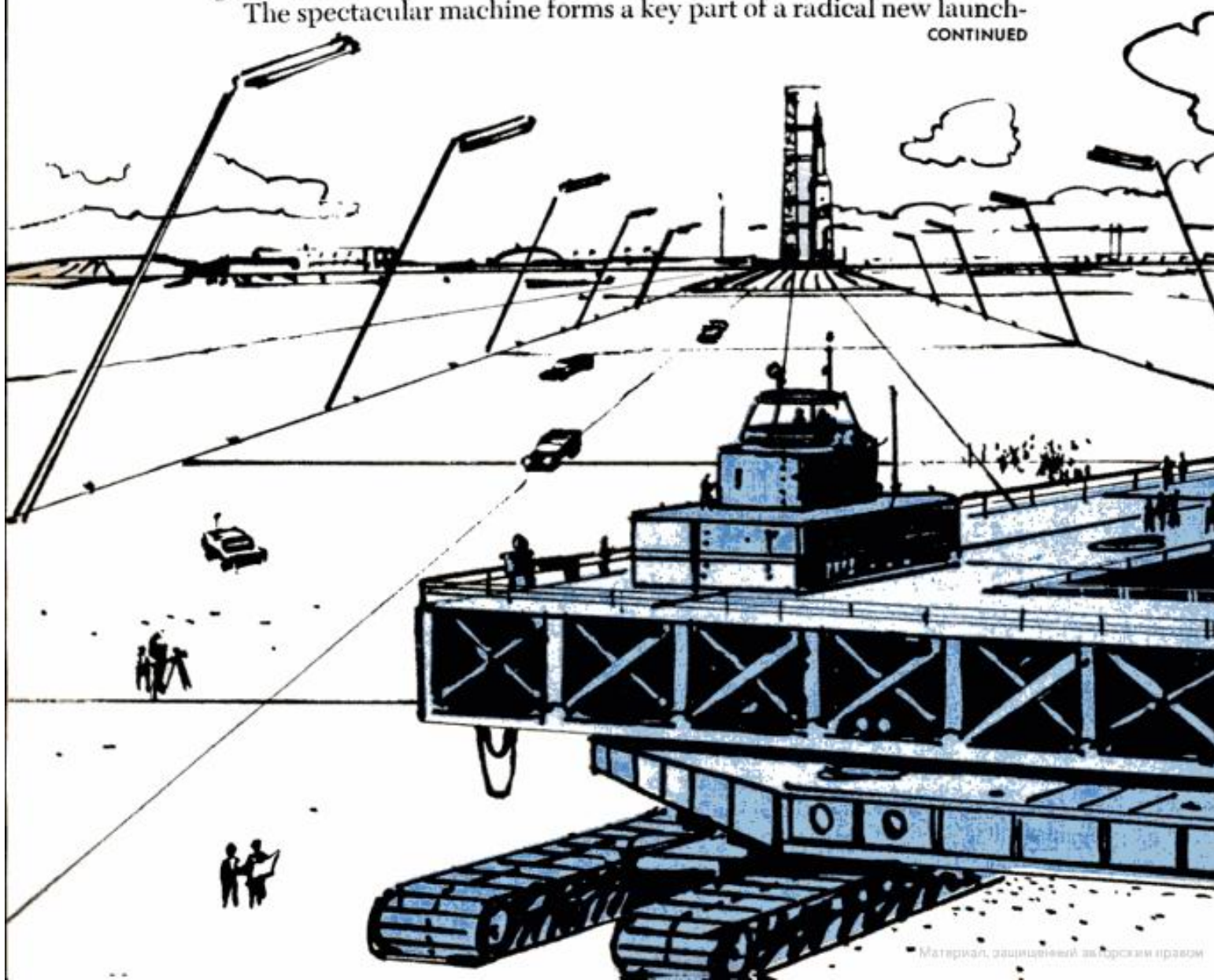
By Alden P. Armagnac, with drawings by Bob McCall

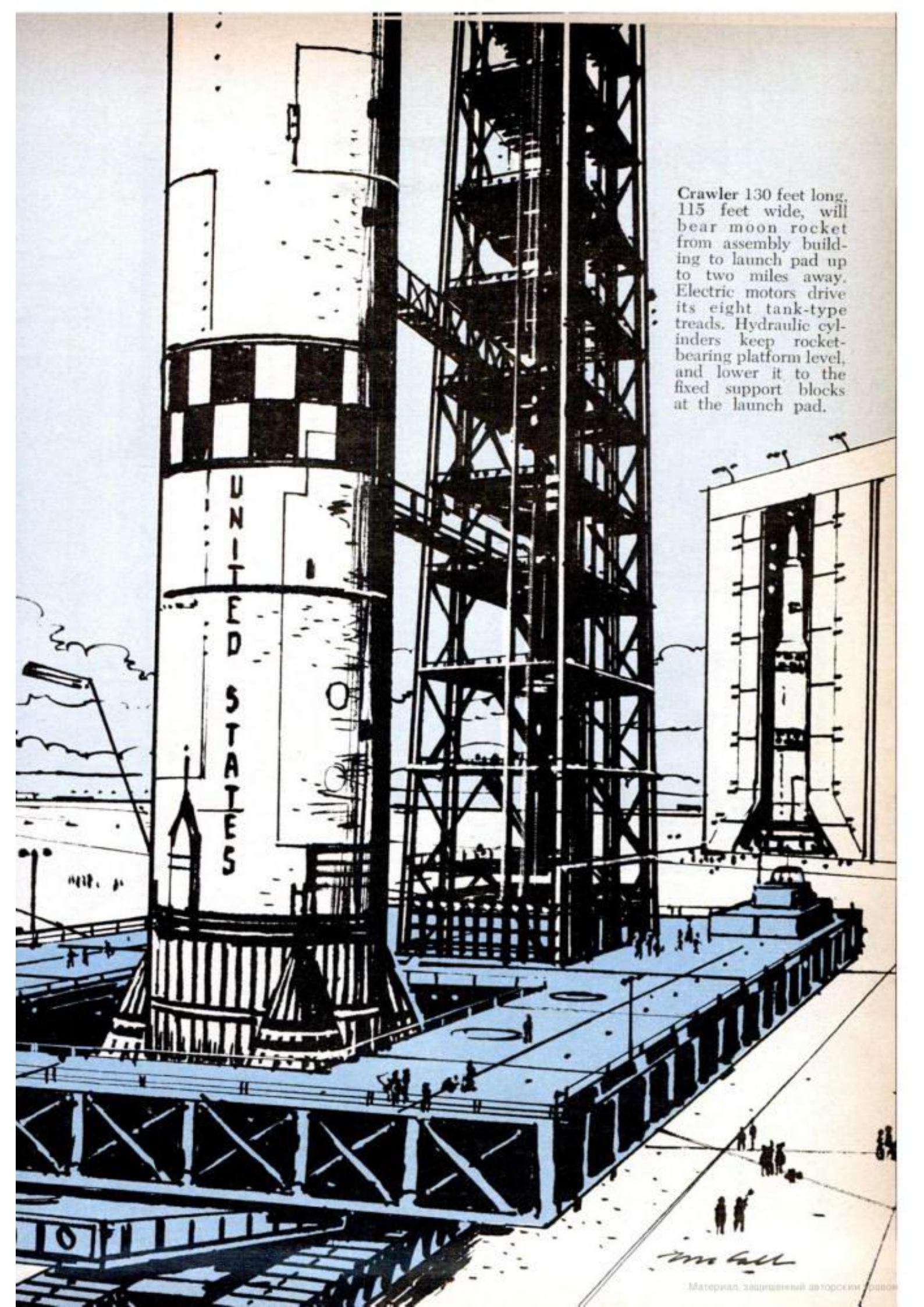
UP-ENDED on a crawler bigger than a baseball diamond, our 350-foot moon rocket will march dramatically two miles along the skyline from assembly building to launch pad.

Powered by diesel generators and electric motors, the enormous carrier vehicle will move on eight tanklike treads. It will bear the Advanced Saturn rocket and its umbilical tower on a 2,000-ton self-leveling platform, which the crawler will lower to blocks at the pad. Then it will back away to safe distance from the blast-off.

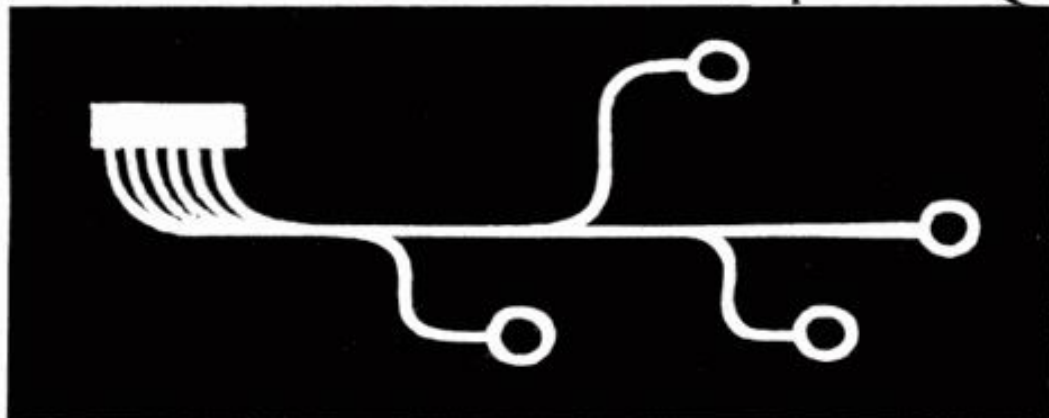
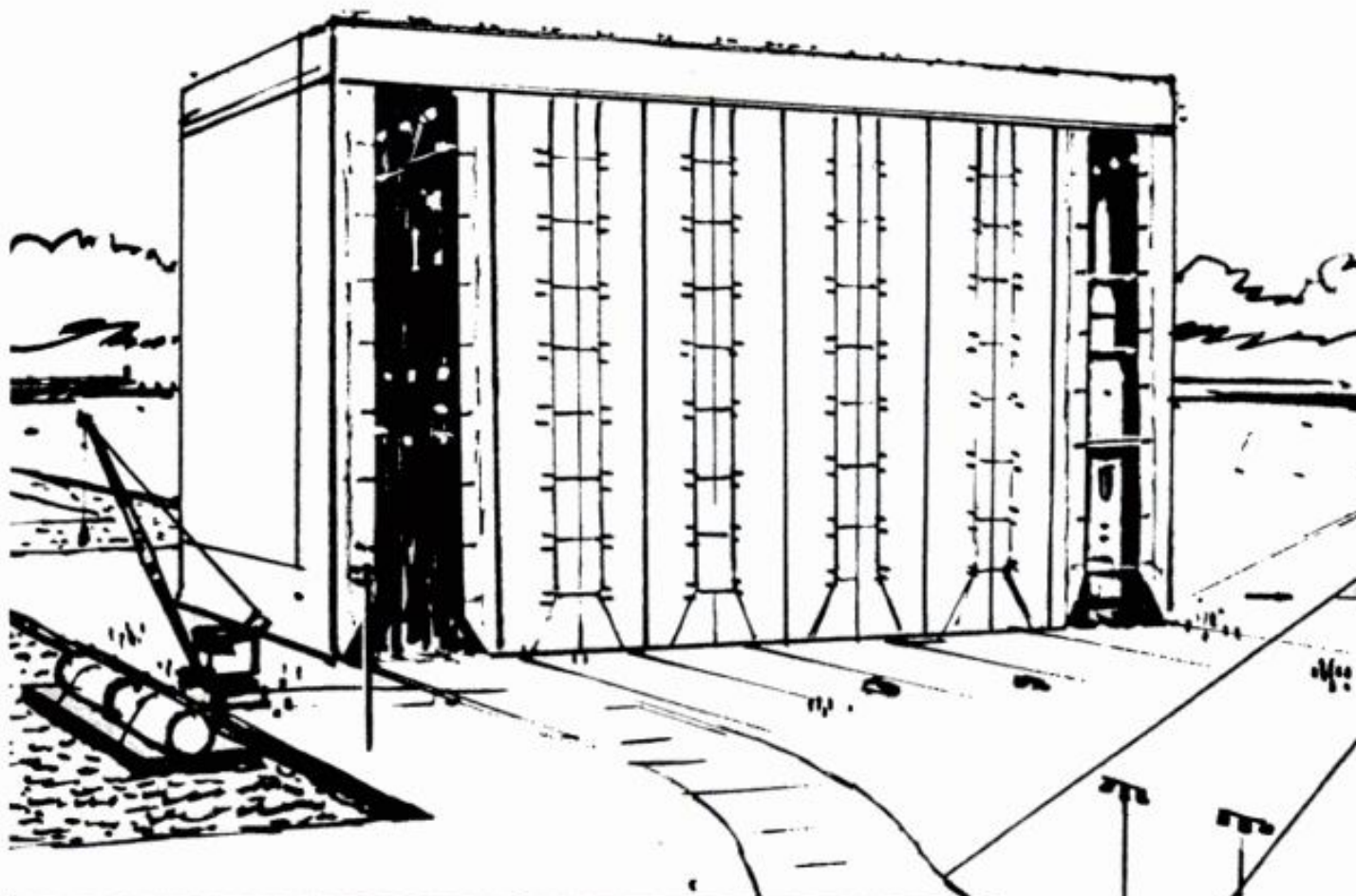
The spectacular machine forms a key part of a radical new launch-

CONTINUED





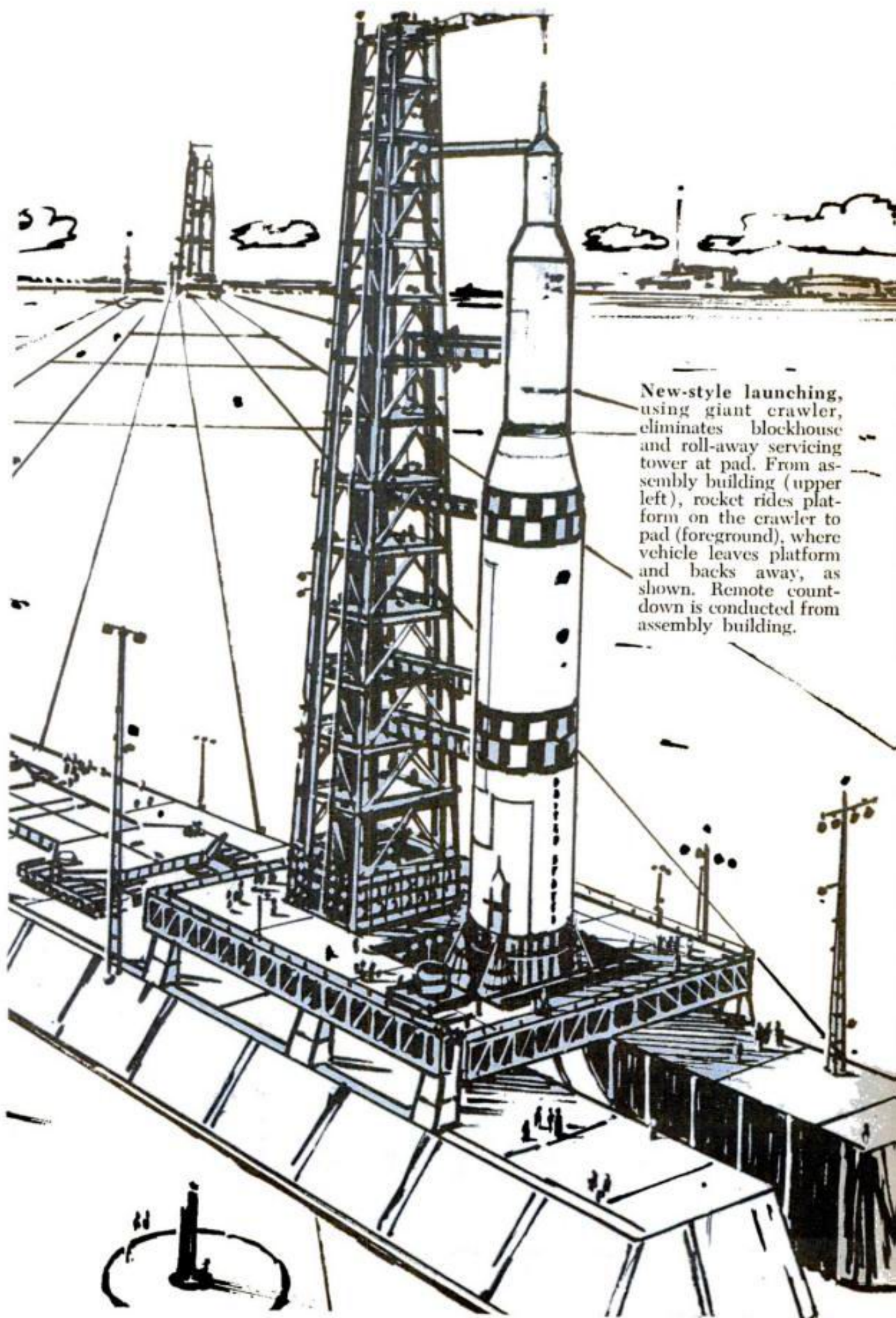
Crawler 130 feet long, 115 feet wide, will bear moon rocket from assembly building to launch pad up to two miles away. Electric motors drive its eight tank-type treads. Hydraulic cylinders keep rocket-bearing platform level, and lower it to the fixed support blocks at the launch pad.



Six-bay assembly building and four launch pads will permit launching biggest rockets in rapid succession—or even in salvo of several at once.

ing procedure, required by coming super-rockets' colossal size, and due for use by 1965 in the Advanced Saturns' about-to-be-constructed "Complex 39" at Cape Canaveral, Fla. Arriving in sections by barge canal, the 7½-million-pound-thrust rocket will be assembled in a 48-story-high building housing six at once. Almost completely checked out for launching before being borne to the pad, it will simply be fueled there—and the launching countdown will be completed from the distant assembly building.

Made possible by new computers operable over long lines, this remote countdown eliminates a blockhouse. Gone, too, will be the usual huge servicing tower that rolls away from a pad at launching time; for the Advanced Saturn, such a mobile structure would be prohibitively big and costly. ■ ■



New-style launching, using giant crawler, eliminates blockhouse and roll-away servicing tower at pad. From assembly building (upper left), rocket rides platform on the crawler to pad (foreground), where vehicle leaves platform and backs away, as shown. Remote count-down is conducted from assembly building.

**U. S. missile designer
forecasts:**

What's Coming in Rockets

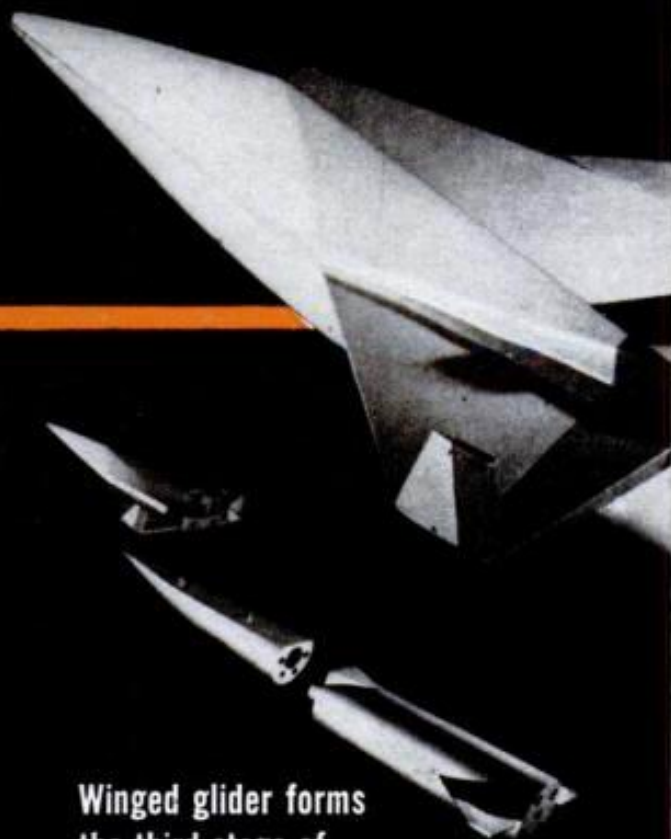


Krafft A. Ehricke is a rocket scientist with Convair, the company building the Atlas ICBM, and chairman of the Space Flight Committee of the American Rocket Society.

By Herbert O. Johansen

A JOINT military-civilian program for U. S. exploration of interplanetary space has been proposed to the President by a group of rocket scientists. Krafft A. Ehricke, who helped design both the German V-2 and our Atlas intercontinental ballistic missile, is their spokesman.

Under this proposal our first foothold in space would be gained by a modified intercontinental-ballistic-missile rocket. Its nuclear warhead would be replaced by a cabin or a cargo nose to carry materials and men far above the atmosphere. There spacemen would (1) build a manned scientific, earth-orbiting satellite station; (2) take the first, cautious, probing steps of space flight—moon reconnaissance and



**Winged glider forms
the third stage of
rocket to boost man into space orbit**

Three-stage arrangement of the 130-foot rocket is shown directly above. Top stage, riding piggy-back on the second stage, would carry a pilot and four passengers into the satellite orbit in the same manner as the automatic



Three-stage rocket would boost supplies into orbit

Separation picture shows three stages of this 126-foot shell-shaped rocket. As two lower stages burn out, they fall back to earth. Top stage speeds into an orbit 600 miles above the earth, carrying a payload of 11,000 pounds. Its fuel tank would become a basic building block in construction of either a manned satellite or a base for exploration still farther out in space.

supply rockets, becoming then a manned satellite itself. It would also ferry personnel between the earth and a space station for the construction of lunar and planetary space ships, returning to earth as a hypersonic glider.

then interplanetary exploration voyages.

Only by a joint venture of the military missile men and civilian scientists can we achieve space flight in our time, according to Ehricke.

"A rocket is a 'weapon,'" he says, "whether you launch it to destroy an enemy target on earth or for the peaceful conquest of space to gain scientific knowledge, and prestige among the world of nations. We cannot afford the luxury of duplication—of non-complementary military and civilian programs."

ICBM rockets, to achieve their military missions, must be able to boost their nuclear warheads, weighing hundreds of pounds, to speeds of 15,000 miles an hour or more, and to altitudes hundreds of miles above the earth. That puts us on the threshold of 18,000-mile-an-hour satellite flight, and brings us close to the 25,000-mile-an-hour speed needed for lunar and interplanetary flight.

Rockets are the hardware of space flight. Their military significance cannot be denied. But out of the atom bomb came the "atoms-for-peace" program. The report submitted to the President by Ehricke's Space Flight Committee of the American Rocket Society recommends the establishment of a national space-flight program under the supervision of an astronautics agency similar to the Atomic Energy Commission and the National Advisory Committee for Aeronautics.

The report also sets forth a six-step program that would make space flight a reality within the next 20 years "without any major technological breakthrough." The goals are these:

1. An earth satellite with a payload of several thousand pounds within *five years*.
2. A payload of several hundred pounds placed on the moon within *five to 10 years*.
3. A similar payload sent out to the nearest planets—Mars and Venus—within *five to 10 years*.
4. A manned earth satellite within *10 years*.
5. Manned flight around the moon within *15 years*.
6. Manned, two-way moon flights, including landings within *20 years*.

Payloads of the *unmanned* vehicles would contain scientific instruments, radio transmitters, TV cameras, animals.

Krafft Ehricke's family of space ve-

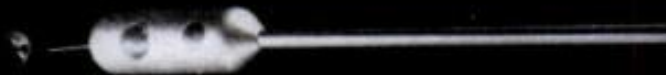


Dumbbell-shaped observational satellite would be assembled by man in the orbit



Around-the-moon-flight rocket ship would take off from satellite orbit

Power for manned interplanetary flight

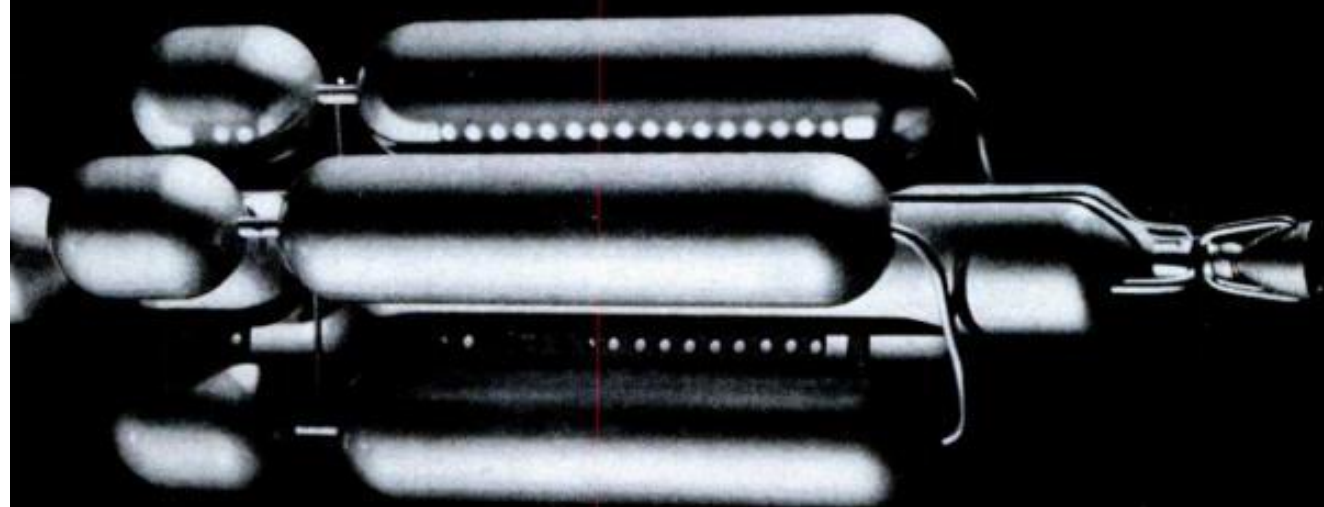


The engine of this slim space vehicle is a nuclear pile that heats a working fluid, liquid hydrogen. The hot, expanding gas, exhausted through a rear nozzle, furnishes thrust as in a conventional rocket. The hydrogen tanks surrounding the pile shadow-shield the crew—



Fuel and oxidizer tanks of the automatic supply rockets would be the basic building blocks for putting together this 400-foot-long space station—and test bed to condition men to space. Crew of four would live and work in quarters at either

end of the vehicle, which would rotate slowly to create artificial gravity by centrifugal force. Center compartment would contain power supply, radar and television for scanning the earth as the station speeds in its 600-mile-high orbit.



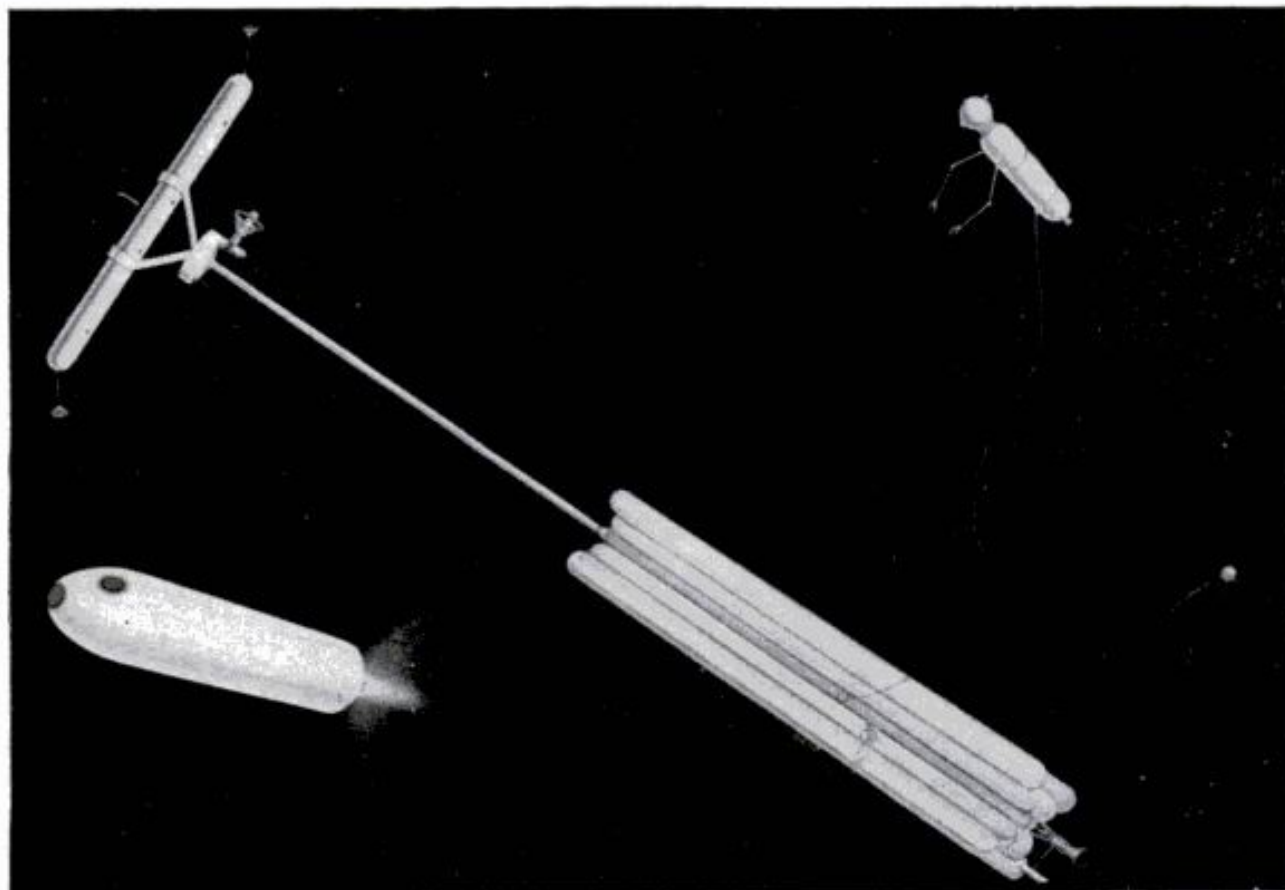
This lunar-reconnaissance vehicle would take man for his first view of the other side of the moon. Assembled in the orbit like the space station, it has four fuel and oxidizer tanks for flight to the moon, and a

fifth one for the return journey. Chemical propellants in use today offer sufficient thrust to give the 150-foot ship the 24,000-mile-an-hour speed bursts that are necessary. The crew sits in a forward gondola.

would be created by nuclear-pile heat

sitting in a gondola 250 feet forward—from harmful radiation. Like the moon ship, this vehicle is assembled in and launched from the earth-satellite orbit. Mars and Venus are within its range. On return to earth orbit, it could be refueled and used again.





INTERPLANETARY SHIP of advanced design has TV robots with mechanical arms that can inspect and service the "hot" nuclear rear por-

tion of the vehicle in flight. Once in a planet's orbit, it can launch small, manned rocket ships for a close-up look at the planet.

hicles is his own, but they are designed to come within the scope of this program. His first step is an automatic, unmanned, three-stage supply rocket, based on an advanced ICBM rocket. The Atlas is reported to be 80 feet long, and to have a thrust of 100,000 pounds, plus about 250,000 pounds from booster rockets to get its 80 tons of weight off the earth.

This is not enough power to launch his 126-foot rocket and boost its 11,000-pound payload into a 600-mile-high orbit. All the big rocket companies, however, have facilities for ground-testing rockets with a thrust of a *million* pounds or more.

Building blocks in space need men to put them together. The rocket power that sends up the unmanned supply ships could also boost the first spacemen into the same orbit. For this Ehricke offers a winged third stage that rides piggy back on top of the second stage. It would return to earth as a hypersonic glider.

Such a manned space ship is not just a dream. We actually have a prototype—in-the-building. It is the North American X-15, which the Air Force expects, before the year is out, may speed man and ma-

chine at speeds approaching 10,000 miles an hour at altitudes perhaps as high as 100 miles.

With men and materials in space, orbiting 600 miles above the earth, the construction of a more livable satellite becomes necessary. Shaped like a dumbbell, it is put together in the orbit, mainly from the fuel and oxidizer tanks of the automatic supply ships. Small rockets would set it into slow rotation, creating a pleasing artificial gravity of about one-third that on earth.

This is a more modest proposal for a space station than some that have been suggested, such as the "City in Space" of Darrell Romick, a scientist of the Goodyear Aircraft Company's astrophysics department, described in the May, 1956, issue of *POPULAR SCIENCE*. Ehricke believes, however, that his satellite platform is adequate as a service station for man's initial ventures into space—with destination moon next on the itinerary.

His lunar ship is strictly a reconnaissance vehicle for flights around the moon and back to the earth orbit. It also would

[Continued on page 244]

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MAN-POWERED RACERS

break 60-mph barrier

BATTERY-SAVING FLYWHEEL

gives electric car
freeway zip

New-technology monster transports

will dwarf today's
jumbo jets

SPECIAL SECTION:

How U.S. '81

cars will

meet the

fuel challenge

Cadillac's wild

4-V6-V8

1000 miles in

Chrysler's

car

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New-technology monster transports

will dwarf today's jumbo jets

By BEN KOCIVAR

Seated in the cockpit of Pan American's new Lockheed L-1011-500 Tri-star, I could look out over the 164-foot-long wings and see huge Boeing 747's and McDonnell Douglas DC-10's trundling along the runways of New York's JFK International Airport. Despite the many trips I've made in them, they still seem too big to get airborne. But they do. And even bigger flying machines are on the way.

Today, I was getting a preview of new material, design, and gadgetry used in the L-1011-500 that could lead to airplanes two, three, even four times its size after the 1990's. As you can see from the pictures, these idea planes are startling departures from today's designs. All are products of joint Air Force/NASA/industry investigations aimed at giant civil-military transports. But just as the Air Force/Lockheed C-5-A technology led to today's jumbo jets, these concepts will

likely lead to super-size passenger airliners in the decades to come.

Is bigger better?

NASA and military planners think so. First, we need to carry bigger, bulkier military loads quickly over greater distances. And second, bigger planes could move more for less money, a critical concern for all users.

To be efficient, these future behemoths will need to be as light as possible. Captain John Harris, Pan Am's check pilot for the new Lockheed jumbo, explained some of its innovations that point the way.

"First, nine feet was added to the wingspan, giving a higher-aspect-ratio wing, which gives more lift with less drag," he explains. "Normally, that would require a beefed-up structure, which would add weight. Instead, this jumbo has active controls—computer-actuated ailerons. These not only control banking, but also move in unison, almost continuously,

to spoil or add lift on the wing tips. This cancels any extra aerodynamic load on the wing." Result: You don't have to beef up the structure.

Lockheed and others are extending the active-control concept to flaps, elevators, and rudders. They would be smaller, lighter, and create less drag. Active controls also reduce aerodynamic loads on the fuselage, so it too can be lighter.

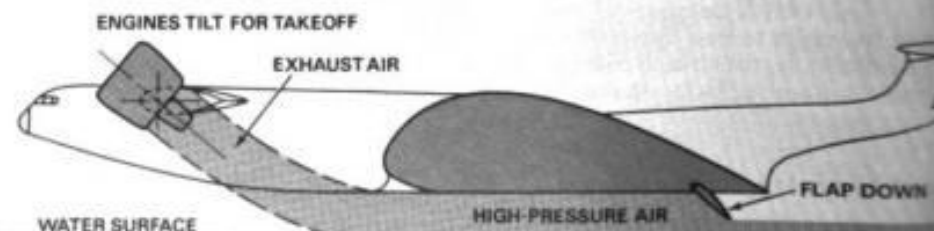
The L-1011-500 has many parts made of composites; they are 25 percent lighter than metal parts. Future monsters would use even more composites. Less weight and less drag mean less power would be required of the new, more efficient engines. Less fuel would be needed, so range and payload could be increased. It's a knee-bone-connected-to-the-ankle-bone concept, and its importance is magnified by the size of these coming giants.

For more on monster transports, see the following pages



In cockpit of new jumbo Lockheed L-1011-500, Pan Am Capt. John Harris briefs author Kocivar on advances that may presage a new class of flying behemoths.

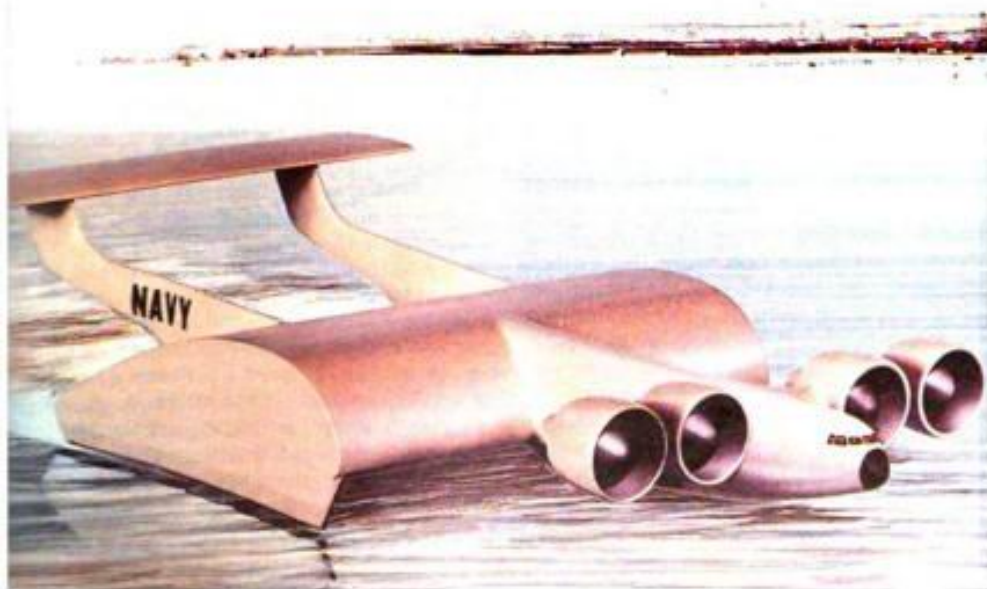
Power-augmented ram Wing-in-ground-effect concept



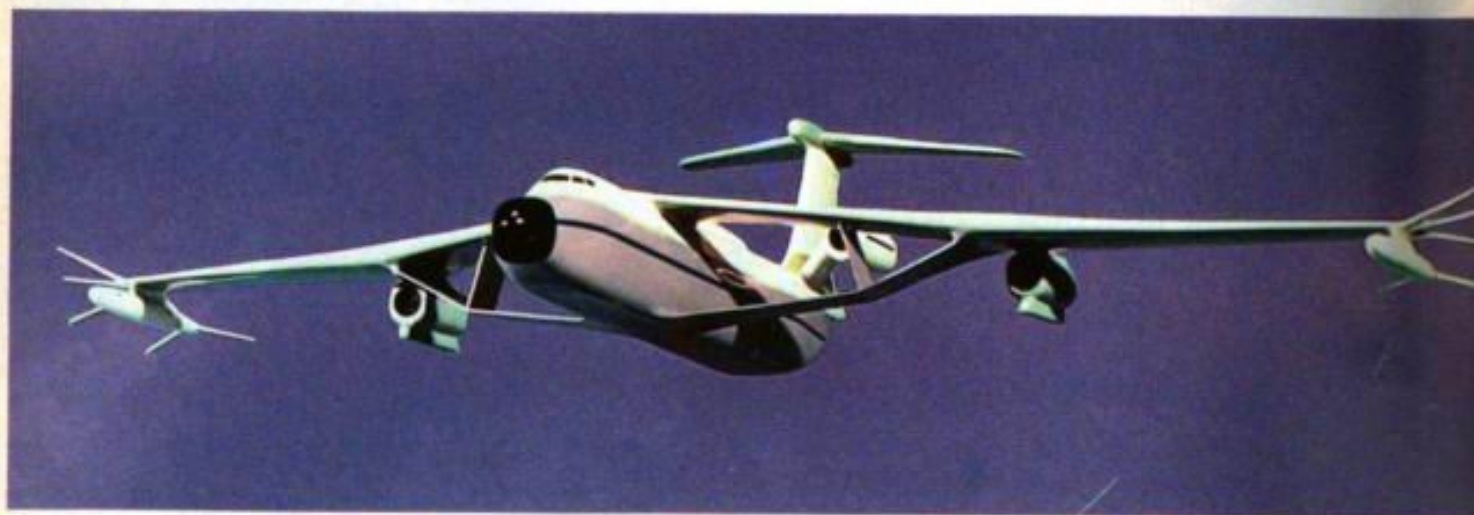


Flat-bed transports could airlift outsize military or civilian cargo. This NASA-sponsored Lockheed-Georgia design has a level loading surface close to the ground. Tanks, such as the 118,500-lb. XMI, or other such cargo could roll on and off. In flight, they'd

be lashed down, and hauled exposed. A half-cylinder pressurized module could adapt the transport for passenger or freight operation. Or containerized cargo could be loaded aboard and covered with a thin cocoon to provide aerodynamic fairing.



Wing-in-ground-effect transports would use a phenomenon that occurs when a plane flies near the surface: Wings get increased lift from a cushion of high-pressure air trapped beneath, and consequently require less power (see "Ram-Wing X-114," PS, Dec. '77). The ground effect extends to an altitude equal to about half the wingspan. WIGE designs usually have stubby (low aspect ratio) wings for better low-speed control. They're usually seaplanes, since they must fly over fairly flat surfaces with wing-tip end plates skimming the wave tops. These NASA/Lockheed concepts (above and left) would use a power-augmented-ram effect (diagram, left) to shorten takeoff and landing. Engines would tilt up, and exhaust would raise pressure under wing. Speed would be only 400 mph, but payloads could be up to 750,000 lbs

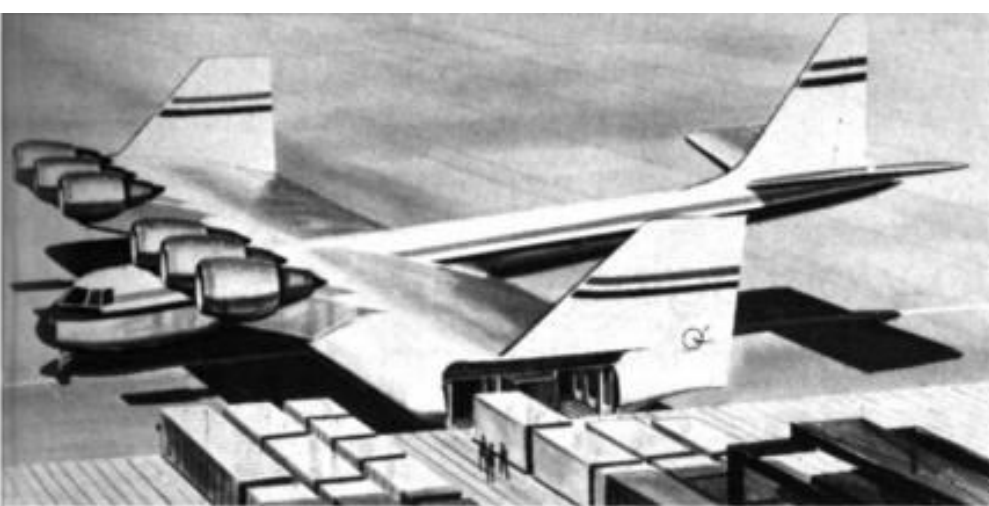


Laminar-flow-control technology would reduce drag dramatically by keeping air flowing smoothly very close to the surface of the wings. Reduced drag increases performance. Result: greater distance and heavier payloads using less fuel. One way to achieve laminar flow is to suck in air through the skin of the wings. This requires a perforated or slotted skin (diagram, right) and a compressor to expel the air. It also requires a system of internal ducts so that the suction air coming from various parts of the wing under different pressures can all be handled efficiently. The result can be spectacularly reduced drag—as much as 10 times less than with a conventional turbulent-flow airfoil.

Laminar-flow technology is particularly attractive for large planes flying long distances (more than 10,000 miles) and at high altitudes. One such NASA concept (above) includes split wing tips to reduce vortex drag (see "Wing-Tip Sails—Aerodynamics Takes a Cue From the Birds," PS, April '79). The 410-foot-long, high-aspect-ratio (long, thin) wings are supported by flying-buttress-like struts from the fuselage. Wings, struts, tail, engine nacelles, and wing-tip fuel nacelles are all designed for laminar-flow control. The long, thin wings and thin struts give this plane a lift-to-drag ratio of 48:1, comparable to very-high-performance sailplanes with extremely efficient wings.



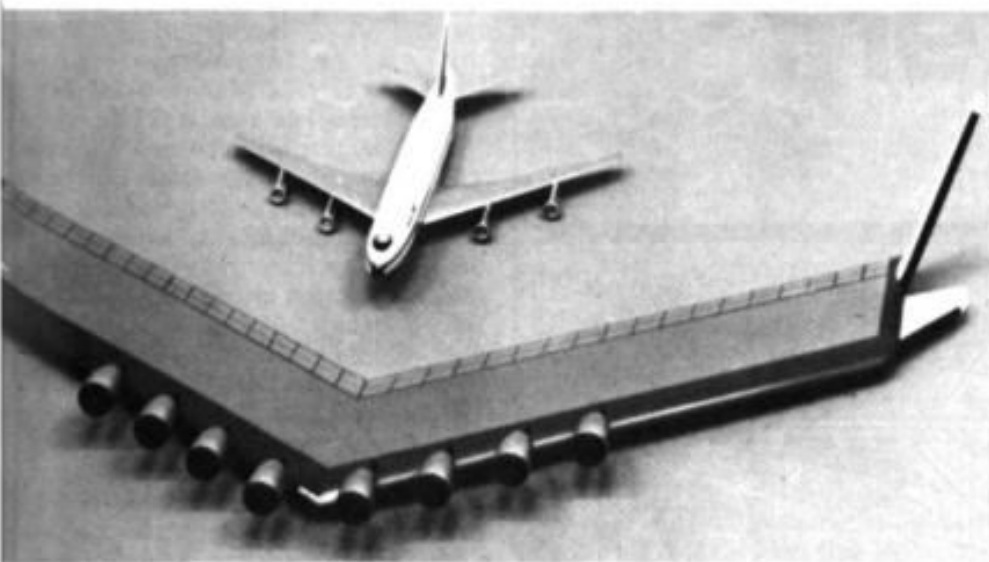
Laminar-flow technology would add weight. Production and maintenance costs would increase because additional care would be required to create and preserve very smooth, clean surface. But the reduced fuel consumption—up to 29 percent—should more than offset these problems. NASA has given high-priority status to laminar-flow technology in its Aircraft Energy Efficiency program.



Spanloaders, with wings 350 to 500 feet long, would carry cargo inside the wings. McDonnell Douglas (top left) and Boeing (left) both have studied this concept. Fully loaded, Boeing's flying-wing design (shown in front of a 747 for comparison) would weigh three million pounds and handle a one million-pound payload.

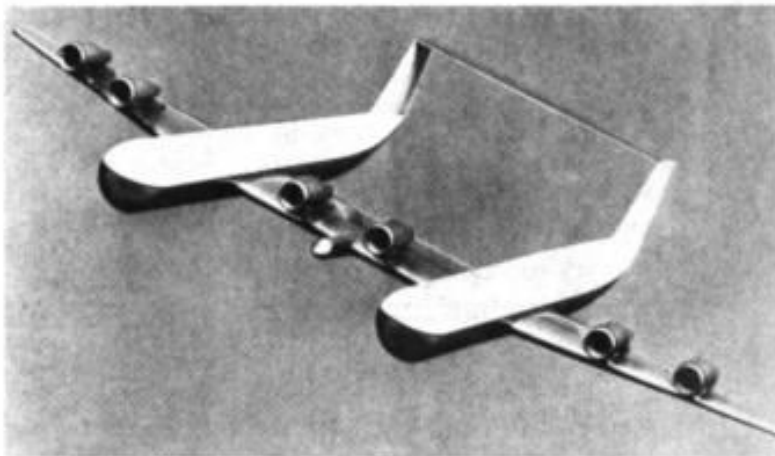
Such monsters would present a problem: Conventional airports do not have runways wide enough or strong enough to handle them. One solution: special hub airports. Smaller aircraft would bring cargo to and from conventional airports to meet the monsters at regional hubs.

Another possible solution: air-cushion landing gears. These have already been proved in flight tests with small amphibians and medium-size cargo transports. The air cushion is a large pocket of high-pressure air under the plane, contained in a "trunk" made of some flexible material. When landing or taxiing, air is blown into the trunk, forming a lubricating film so that there is very little ground friction. With the weight of the plane thus distributed over a large area, it could land on water, snow, or soft ground, or land on water and taxi onto a runway of standard strength, as shown (far left). Air pressure is maintained by bleeding air from the engine or a separate on-board fan. The flexible trunk looks like an open-bottom inflatable life raft. When not needed, it would be retracted to fit snugly under the fuselage. The air cushion would replace conventional landing devices—wheel gears, floats, or skis.



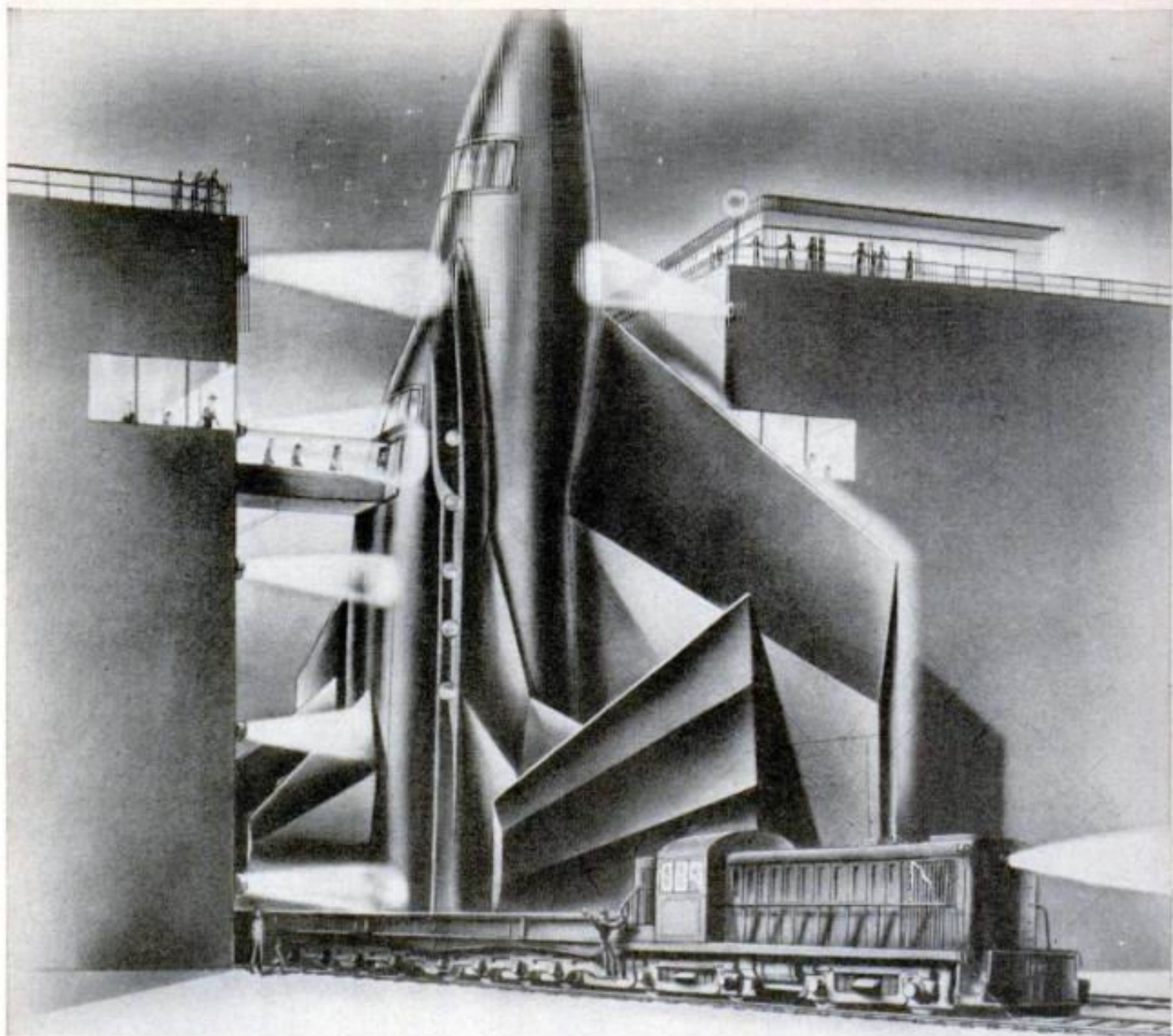
Nuclear power would replace petroleum-derived jet fuel in some advance air-transport concepts. A nuclear-powered plane would have almost unlimited range and endurance, but it would not have enough power to take off and land carrying a big payload. One solution: Use an auxiliary power system burning jet fuel for these operations. Another: Use the nuclear-powered plane as a tug only, as in the Lockheed-Georgia concept, above. Without a payload, the nuclear reactor could supply enough power for takeoff and landing. The planes to be towed—the size of today's giant C-5's—would carry the payload, but would carry only enough fuel for takeoff and landing, plus reserves. During cruising flight, they would be towed behind the nuclear tug, like huge gliders, and use no fuel. The nuclear-tug design shown here has a gross weight of about two million pounds; 40 percent would be the reactor. The plane would be a seaplane, and would fly only over water. If it were to fly over land, the design would have to include protection for the reactor in the event of a crash, entailing a heavy weight penalty. The nuclear-powered plane assumes advanced nuclear technology.

Other alternative-energy concepts have been designed by Lockheed for NASA. They include planes that would burn liquid hydrogen, liquid methane, or jet fuel made from coal.



Multibody aircraft, with two or three fuselage sections, would have many structural benefits of the giant spanloaders, but would not require extrawide runways, and thus could land at existing airports. A multibody plane would probably cost more than spanloaders per ton-mile of freight carried, but enough money might be saved by using today's airports to make up the difference. The photo above and our cover painting show two variations of the multibody concept being considered by Lockheed and NASA. The design above has two fuselages attached to a single wing. Six turbine engines are mounted on top of the wing. The tribody concept shown in the cover painting looks like two Lockheed L-1011 Tristars joined at the tails and flanking a large center wing/cargo section. It has engines in the tails as well as under the wings. This tribody design would weigh 1½ million pounds and carry a payload of 441,000 pounds. Half would go in the center fuselage and 25 percent in each outboard fuselage.

Roy Lange, manager of Lockheed-Georgia Company's Advanced Concepts Department, points out an additional advantage of the multibody concept compared with a single large fuselage: Loading and unloading could be done faster. Only limited studies have been done of these two designs, but several twin-body airplanes have flown in the past.



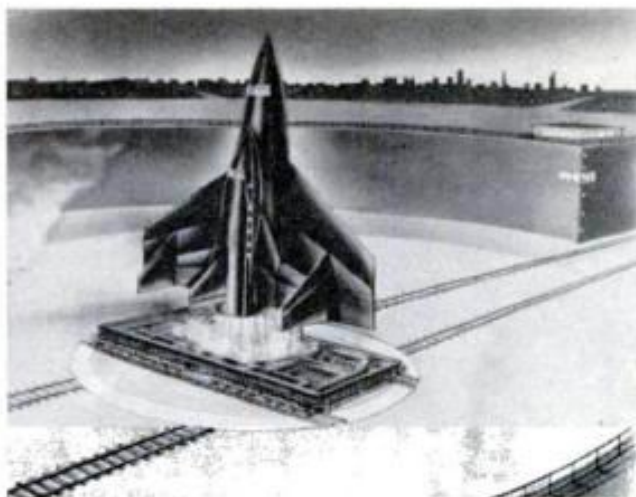
1 BOOSTER UNIT and its piggyback passenger ship would stand in nose-up, rocket take-off position during loading. A train would tow the 300-ton combo to the launching site.

Rocket Liner Would Skirt Space to Speed Air Travel

DESTINATION Earth is a new twist in passenger-carrying spaceships. Spanning the U.S. or the Atlantic would take an hour and a quarter, the Pacific an hour and a half. A piggyback ride on a booster rocket would start this super-liner of tomorrow on a fantastic flight to an altitude of 200,000 feet and a brief

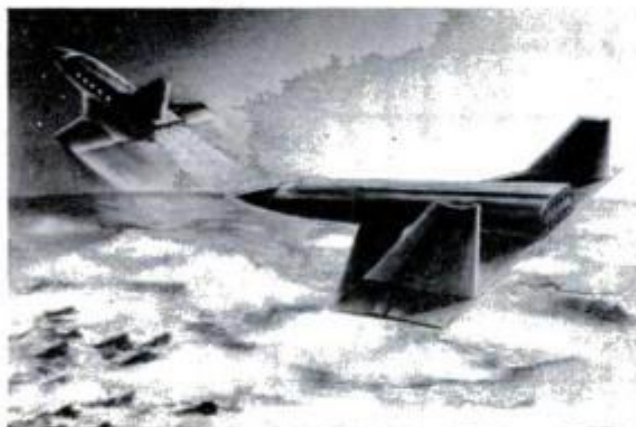
top speed of 17,500 miles an hour, 24 times the speed of sound.

How this high-speed, globe-girdling air travel would be accomplished is shown in these drawings. They are based on design proposals of a Bell Aircraft Corp. scientist, Dr. Walter R. Dornberger, who worked on German V-2 rockets.



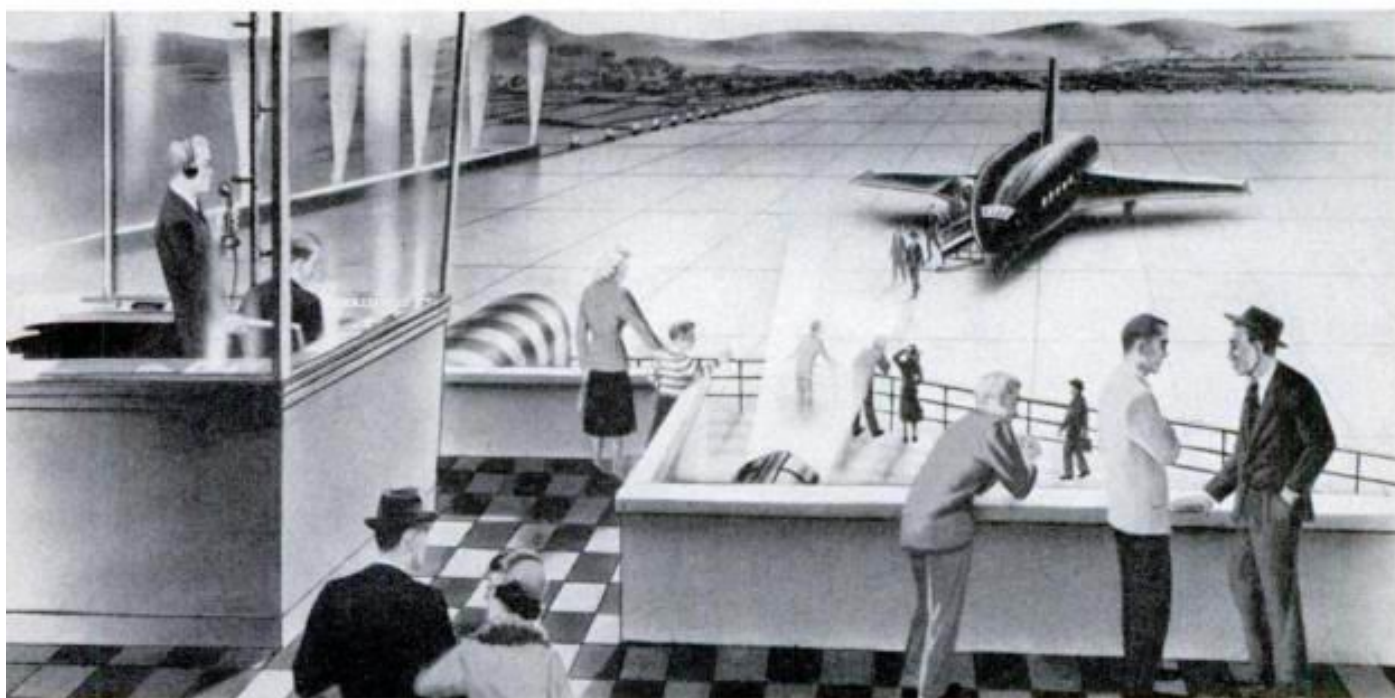
2 LAUNCHING would be from the center of a heat-resistant pit, with eight rocket motors blasting off with a thrust of 760,000 pounds. Both booster and plane units are crew-manned.

4 TWO MINUTES LATER, at an altitude of 70,000 feet, the passenger rocket would blast itself free from the booster, as the latter cut its rockets and glided back to base.



3 DURING TAKE-OFF, passenger seats would be one above the other on each side of an aisle. They would rotate on a horizontal axis when the ship leveled off in flight.

5 PASSENGER PLANE'S ROCKETS would blast it spaceward for about two minutes, then be cut. Silently it would continue to climb, then lose speed and glide back to earth.



6 SUPERSONIC SPACE-BRUSHING FLIGHT would end in a gentle glide through the lower at-

mosphere, landing on a runway in the manner of a conventional airplane.



This Bus Rolls Through the Sky

Mount Hood in Oregon gets longest passenger-carrying aerial tramway.

By Richard L. Neuberger

IT WAS a great day when the first bus arrived at Timberline Lodge, halfway up Mount Hood's icy slopes, in the autumn of 1937. This bus arrived as busses generally do—on the ground. It was an even greater day in the late spring of this year when a bus reached Timberline as busses only rarely do—through the air.

The vehicle was a twin-motor coach of 370 horsepower, like the ones that rumble over the asphalt of hundreds of American cities and towns. But this one had no con-

tact with asphalt or any other road surface. It came in at treetop level like a hedge-hopping airplane and deposited 36 enthusiastic passengers on a wooden platform far above the snow.

This most extraordinary of busses now leaves every hour on the hour for the partial ascent of the highest mountain in rugged Oregon. It climbs from the 3,800-foot notch on the south side of Mount Hood to the 6,000-foot elevation of famous Timberline Lodge. The terminal is 53 miles east of Portland, on State Highway No. 50.

Riding cables suspended from 40 deeply anchored steel towers, the cloud-scraping sky coach swings up the mountain for 3.1



Aerial bus, seen in mid-air on opposite page, starts ascent from roadside terminal above.



Driver uses these controls to maneuver the sky-riding bus. Part of driving that calls for most skill is getting car over cables' supporting "jacks" without excessive jolting.



Passengers have magnificent aerial view of scenery as 36-passenger bus rides up and down the slopes of Mt. Hood on cables stretched between A-shaped towers 50 to 600 feet apart.

miles. This makes it the longest passenger-carrying aerial tramway ever built. The car gains more than 700 feet in altitude for each mile traveled. It takes 24 minutes to make the uphill journey with a full load. Running time on the descent is 16 minutes.

Unlike nearly all other aerial tramways, the one on Mount Hood has stationary cables. They never move. Nor is there any power equipment at the terminals. All the tractive effort is contained in the bus, which literally hoists itself along the heavy lines by means of traction cables below and parallel to the weight-supporting cables.

On each side of the bus, a traction cable passes in turn over an idler pulley; around the front "wheel," which is actually a power-driven pulley; around a similar rear "wheel"; and over another idler pulley, which unreels the traction cable at the rear as fast as it is reeled in at the front. When flat pancake-type motors at the bottom of the bus get busy, the car rumbles up the cables to Timberline.

Because these coaches are so much like the bus that hauls you through town and city streets, a ride on the Mount Hood tramway is all the more a novel experience.

Aerial bus swoops on fixed cables, supported at each of the steel towers by "jack" seen at

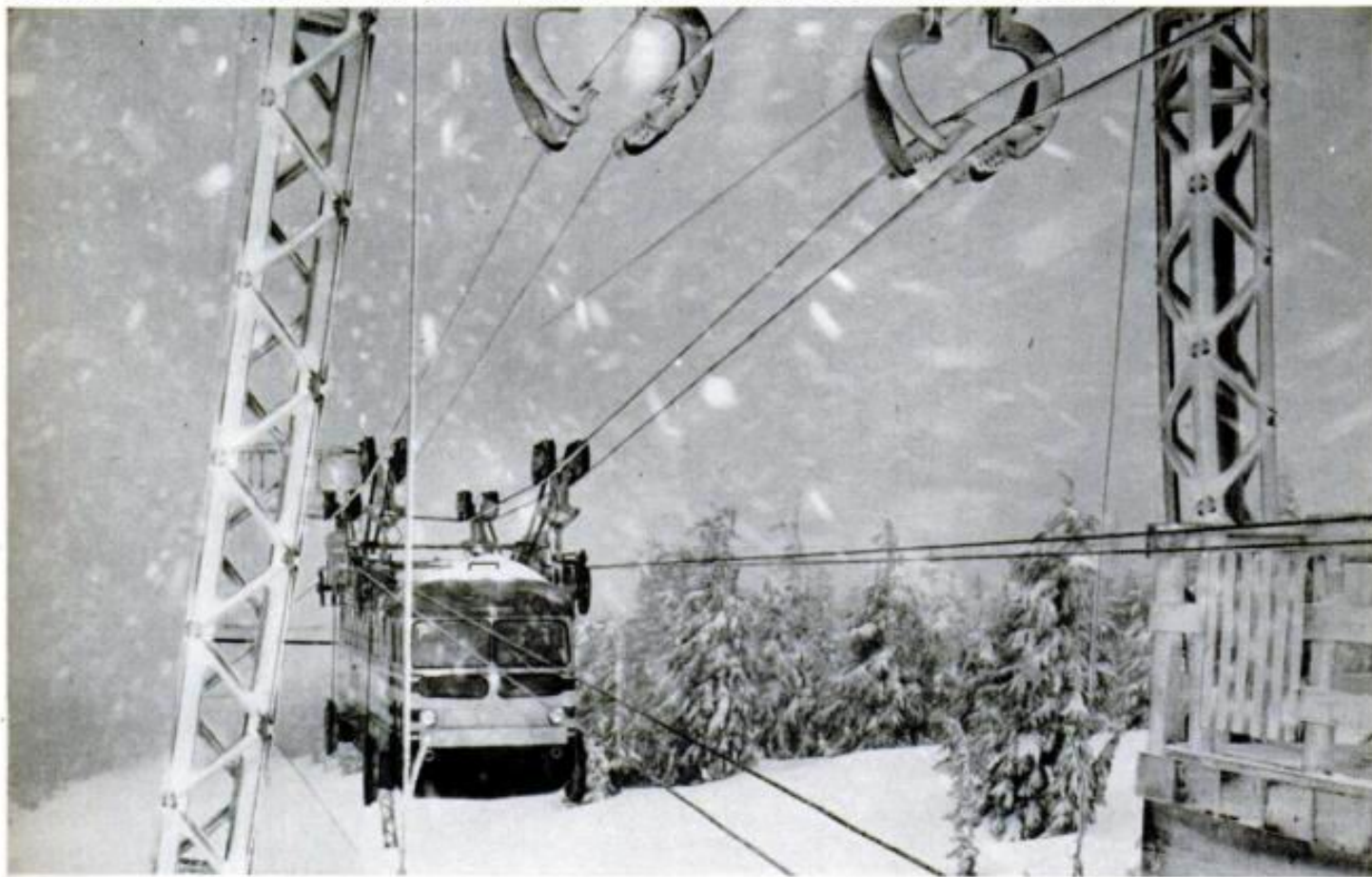
You glance out the window expecting a bus rider's customary view of store fronts. Instead, you look at treetops or thin air. In many places the coach sways 70 feet above the ground. There are no truly dizzy gaps below, such as at Sugar Loaf Mountain in Rio de Janeiro, in Brazil, for the Mount Hood "cloud liner" parallels the general contour of the earth. But the panorama from its leather seats makes the pulse throb faster. And that is the main reason why \$750,000 has been invested in building the project. It is essentially a scenic venture.

Tourist Gets 150-Mile Aerial View

On the twisting gravel automobile road to Timberline, the majestic view was obscured by foliage and switchbacks. Now the tourist who has paid \$1.50 for his round trip on the tramway can gaze out across the picturesque face of Oregon for nearly 150 miles. Not a wisp of vegetation interferes with his vision.

Out of the green sea of fir and pine timber, the extinct volcanoes of the Cascade Range loom like white frigates. Mount Jefferson is a snowy mainsail that seems close enough to touch with an alpenstock. And

top of the picture below. In many places, vehicle soars 70 feet above the ground.





Upper terminal of 3.1-mile sky ride is at the 6,000-foot level of Timberline Lodge, halfway

up Mt. Hood, Oregon's highest peak. In making climb, the car gains 2,200 feet of altitude.

there, far off to the west, is the blue streak of the Columbia River. On the eastern horizon a desert of sagebrush chokes off the lush forests. This line of demarcation is as sharp as a moat. For camera fans, each passing foot of elevation on Mount Hood's steep ramparts unfolds a new vista.

Winter Interrupted Work

It took almost two years to root the 40 towers to the windswept apron of the 11,245-foot mountain. Men could work only from May until October because ice and snow reign on Hood the rest of the year. No road or trail offered access along the 3.1-mile route of the tramway. A series of steep ruts for trucks and "cats" had to be bulldozed before sacks of cement and sand could be dragged up the mountain-side for the massive foundations on which the A-shaped towers would rest.

Terrain decided both the height and number of towers. Some are 40 feet high, others 72 feet. A few towers are only 50 feet apart, but many are separated by 600 feet of swinging cable. The concrete abutments, in which the uprights have been rooted, are 16 feet deep. The towers stretch up the slope like a centipede of steel.

Two Busses Needed in Busy Season

Two motor busses provide the mobile equipment. Usually the second coach is operated only on week ends or at the peak of the ski season. Both must head in the same direction, for there is only one sky "track." They can't pass each other. The two busses must be at least 10 towers apart to avoid undesirable tension on the cable.

Is the route dangerous? The maximum incline slants at 28 percent. A few passengers have uneasy moments when they look



Skiers alight after ascent. Bus climbs under own power by reeling in traction cables at front and unreeling them in rear. Idler pulley, top, guides cable to power pulley below.

down and wonder what would happen if the law of gravity suddenly went into unrestricted operation. But each bus is fitted with a complete set of air brakes. These clamp tightly on the wheels with brake bands almost an inch thick. If a leak or line break should cause the pressure in the

[Continued on page 212]

8,000-foot wind-power tower

Solar energy would create a 150-mph wind in this gigantic chimney

By ERNEST F. BLASE
and JEROLD H. KLAIMON
ILLUSTRATION BY DEAN ELLIS

You've been aware for miles of a gray tower looming on the desert horizon. The closer you get, the more awesome it is, dwarfing any structure you've seen or imagined.

Soon another mystery: The arid land has given way to rows of robust crops. Here's a gentle, cool breeze.

Suddenly the fields end, replaced by damp black asphalt. A brisk wind and a loud "whoosh, whoosh" suggest what this gargantuan structure is.

The tower is a windmill of sorts—an aeroelectric plant. It's a simple concept, despite the tower's great size. Water, piped from the sea, is pumped to the top of the 1½-mile-high, 900-foot-diameter tower and sprayed through atomizers. It evaporates, cooling the hot, dry air. This cooled, dense air falls down the chimney and drives 10 wind turbines, which generate electricity—2,500 megawatts at peak; about 1,000 MW average.

Such a mammoth windmill doesn't yet exist, but an El Segundo, Calif., engineering firm, Agbabian Associates, has been studying the concept since 1978. The idea actually dates to 1965, when Dr. Phillip Carlson was working on a desalination project at Lockheed. "It involved condensing water inside a chimney," he recalls. "We ran some calculations and found that, theoretically, we'd get out eight times the energy we put in to pump the water to the top of the chimney.

But, in 1965, there didn't seem to be any need for new energy sources."

By 1974 the need was apparent, so Carlson resurrected the concept. In 1978 he joined Agbabian Assoc.

Power in volume

A comparison with a hydroelectric power plant illustrates why an aeroelectric plant must be so large. The quantity of power produced by both systems depends on the volume, density, and velocity of the working fluid: water in the hydroelectric system, air in the aeroelectric. Since air is much less dense than water, an aeroelectric system requires about 1,500 times more air than a comparable hydroelectric plant uses water.

Some of the power produced would operate ancillary equipment, and there would be power and friction losses. These amount to proportionally less in larger systems—another reason to build them big.

The proposed 2,500-MW aeroelectric plant would use 140 million cubic feet of air per second, which would require 1,000 cubic feet of water per second. Only the ocean would serve.

The velocity of the air coming down the chimney depends on the temperature difference between the air on the inside and that on the outside. The hotter and drier the ambient air, the more it could be cooled by evaporation. Thus the greater the temperature difference, the greater the power output. Consequently, aeroelectric towers are proposed only for desert areas.

Because hotter, drier air results in greater power production, an aeroelectric plant would produce maximum power on summer days and the minimum on winter nights. That, coincidentally, matches the demand curve of most electric utilities.

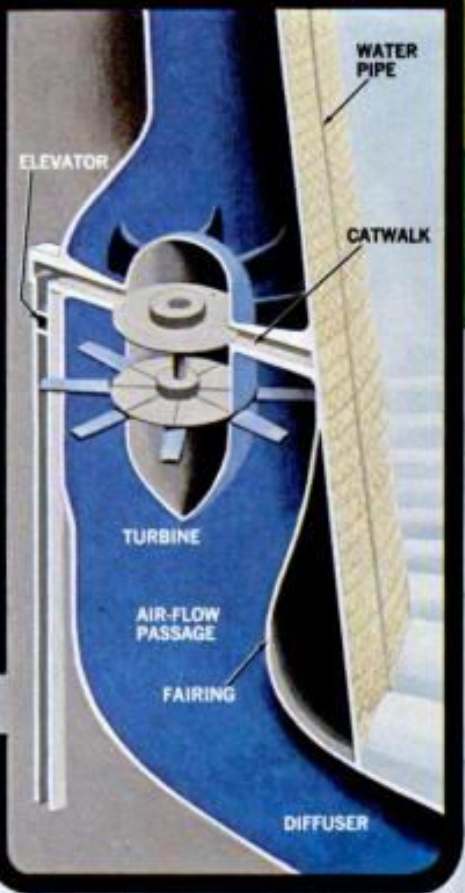
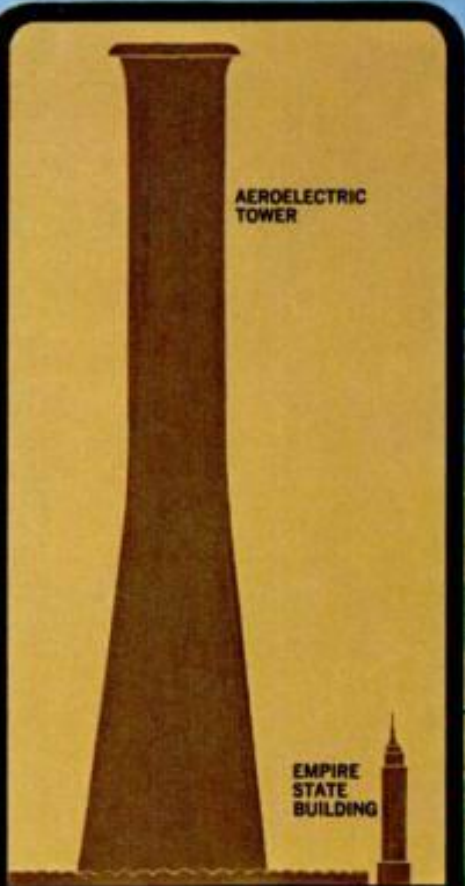
Agbabian admits that constructing an 8,000-foot tower presents a challenge. The current proposal calls for using prefabricated concrete modules with an inner wall only a foot thick strengthened by a lattice of concrete beams extending 30 feet out.

Just how much such a plant would cost is hard to say, but the company believes it would compare with other large power plants ("on the order of two billion dollars"). And it would be substantially less expensive to operate. The 2,500-MW tower would produce electricity at about one-third the cost of an oil-fired plant, Agbabian concludes, and significantly less than a coal or nuclear plant.

While an aeroelectric plant poses no known environmental hazards, it would certainly modify the microclimate. Air temperatures at the base of the tower would average about 30 degrees below ambient, and a 25-mph wind would blow out of the diffusers (the arched openings at the base of the tower). A salt-removal system is designed to take 99.9 percent of the salt from the sea water. The brine would collect in the diffusers and on the asphalt and be piped back to the sea.

The remaining moisture in the air would condense out at night as a very heavy dew, "... equal to 40 inches of rain per year near the chimney," says Carlson, "tapering to 20 inches three miles away."

Agbabian now has a \$5 million grant request ready for DOE. The funds would go for more studies and for a demonstration project that would use the Hoover Dam spillway as a simulated chimney. The next step would be a commercial plant: a 4,000-foot tower, 800 feet in diameter, producing 500 MW at peak power. [3]



Idany Ellis

Material, manufactured by the author

Wave power

spins a ram-air generator

● An ingenious new concept to generate electricity, using the power of ocean waves, will be tested in a pilot plant off Scotland's Outer Hebrides. The 100-foot-tall concrete structure traps a rising and falling column of water that pumps air through a rotary turbine. Long strings of the devices might prove economical for remote islands.

By **DAVID SCOTT**
Painting by Dean Ellis

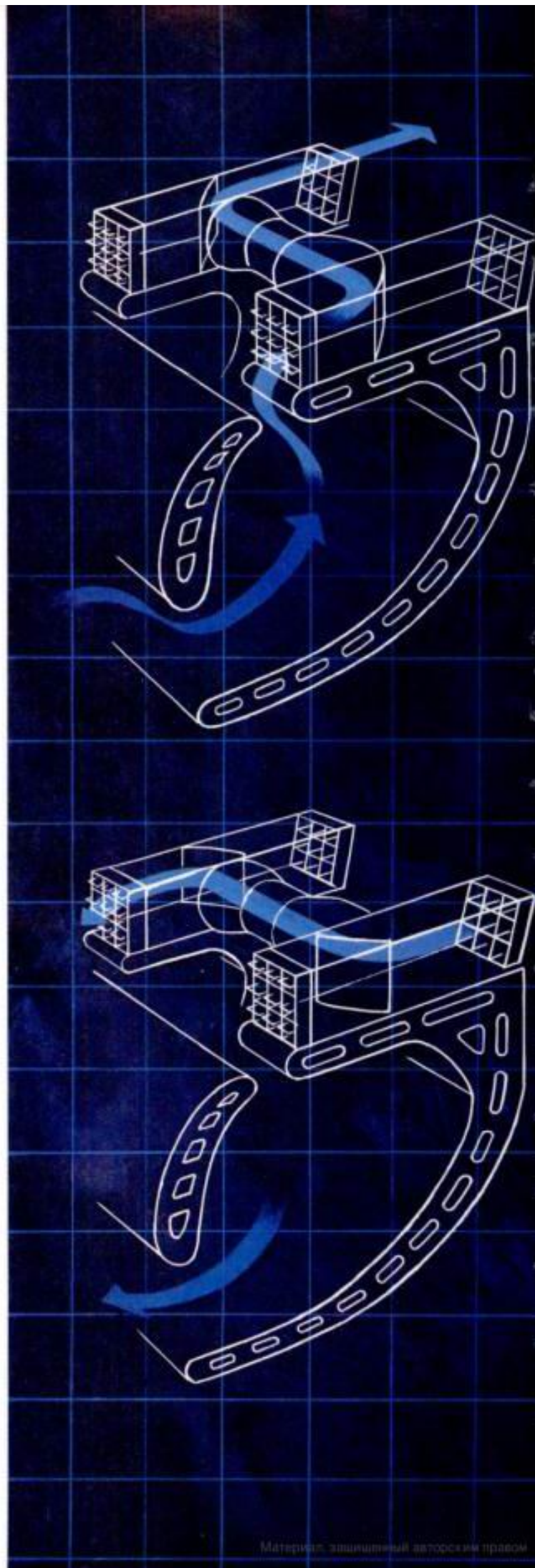
The legion of wave-energy-conversion devices includes some very exotic beasts. Regular readers of *POPULAR SCIENCE* will remember the "nodding ducks" [PS, Nov. '77], flexible rafts [PS, Sept. '78], wave-tuned plates [PS, May '79], and floating turbines [PS, Oct. '80] that British and Japanese inventors have proposed to convert the energetic passage of ocean waves into a steady flow of electricity. Many of these floating or tethered rigs now languish in that engineering limbo where imaginative but impractical energy solutions rest in peace.

They had three sorts of problems: Submerged mechanical parts, such as hinges, spring joints, and seals, proved vulnerable to the continuous buffeting of the sea; tethers and moorings could slip or break in winter-storm conditions; and the limited back-and-forth motion of their energy-absorbing elements could not be converted to electricity with high-enough efficiency.

But now the British have come up with a wave-energy device that may stand up to the harsh ocean environment while economically producing electricity for remote islands. The wave-power breakwater, developed by hydrodynamics specialists at Britain's National Engineering Laboratory (NEL) near Glasgow, Scotland, generates electricity by ramming air through a standard turbine-generator set. The air is driven by a powerful column of seawater inside a concrete chamber that acts like a piston as the waves rise and fall.

Because the breakwater is concrete and is planted solidly on the seabed, and its mechanical and electrical equip-

Continued



The energy of ocean waves is transferred to flowing air in giant concrete breakwater's snail-shape chamber so the turbine and generator, enclosed 46 feet above the waterline, remain isolated from the ocean's rigors. The modules planned for Scotland's Island of Lewis will generate four MW of electricity, to be carried ashore by submarine cable. The diagrams (left) show how one-way valves and louvers route airflow through the H-shape ducting between the wave chamber and atmosphere. Water level in the chamber rises and falls like a piston with the crests and troughs of incoming waves. On the upstroke (top), air is forced out of chamber, past flap valves and louvers, through turbine, and then past diagonal set of louvers and valves to the atmosphere. On the downstroke (bottom), negative pressure pulls air on an alternate route, but the flow through the turbine is always in the same direction. The valves and louvers operate automatically under air pressure.



First Photos of Peru's Great Wall

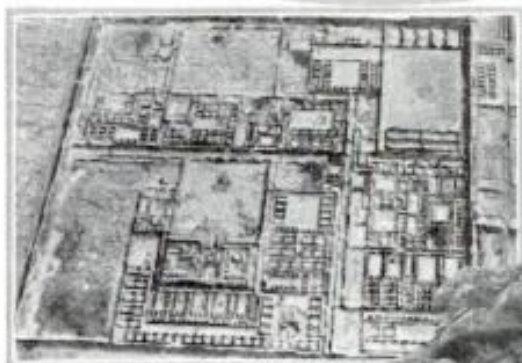


At right, air view of Peru's Great Wall showing how it passes into the heart of the Andes. Above, explorers' plane after smashing against stone wall. At center are leaders of the expedition, George Johnson, elbow on engine, and at his left young Robert Shippee. Below, map of route followed by the two explorers

© Aerial Explorations, Inc.



At left, an air photo of the ancient palace city, Chan-Chan, which was built long before the Incas arrived

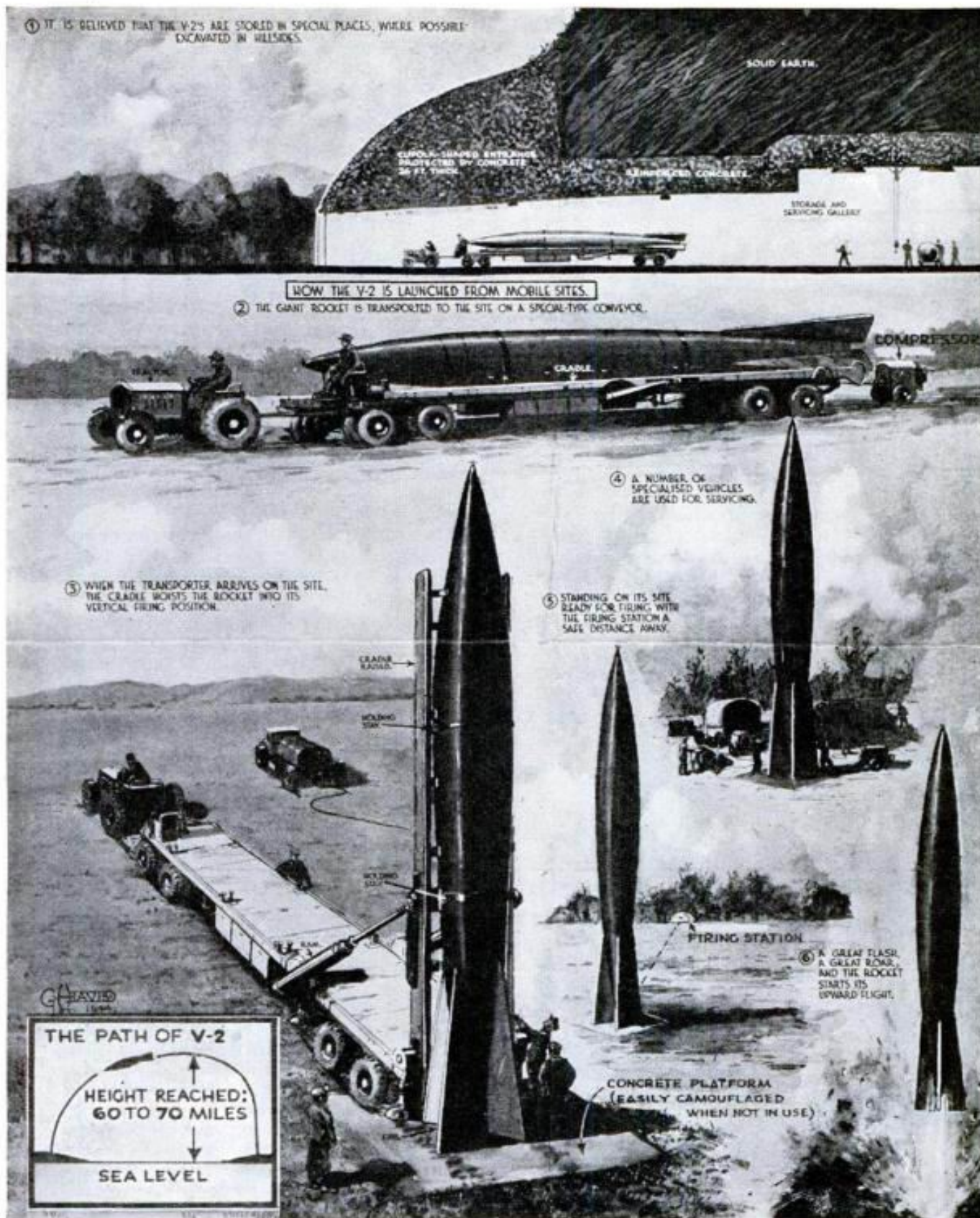


FIRST photographs of the amazing "Great Wall of Peru," discovered not long ago by the Shippee-Johnson Expedition in South America, dispel all doubts that this world's wonder actually exists.

By foot and airplane, the two youthful American explorers traced its course from its beginning, near the seacoast town of Chimbote, for forty miles through the Andes until it disappeared in a mass of mountain peaks and ridges. Made of stones cemented with adobe, the barricade rises at some points thirty feet high. It is believed to have been erected at the dawn of the Christian era by the Chimus in a vain attempt to protect their highly cultured civilization. Discovery of the wall, resembling China's famous rampart, was the climax of a trip in which the explorers came unscathed through an airplane wreck and a revolution.



Robert Shippee, twenty-year-old discoverer, inspects the Great Wall which in places rises some thirty feet high



HOW NAZIS LAUNCH V-2 ROCKET

USING an RAF reconnaissance photo made over Peenemunde, Germany, as a guide, artist G. H. Davis drew these sketches for *The Illustrated London News* to show how the Nazis launch the terrifying V-2 rocket.

The bombs are stored, it is believed, in huge caves dug in hillsides and heavily reinforced. They are hauled to concrete firing platforms on big trailers and raised to an almost vertical position before being discharged.

ARCHITECTURE

THE LIVING MUSEUM

For a newly minted museum in San Francisco, the green architecture is the main exhibit

FROM A BIRD'S-EYE VIEW, the domes of the California Academy of Sciences, set to open in the fall, bulge out of the ground like giant scoops of green ice cream. These undulating hills built into the museum's 2.5-acre, flora-covered roof integrate the building into the green space of surrounding Golden Gate Park. They also conserve energy, since the roof insulates and ventilates the 400,000-square-foot museum below.

Designed by renowned Italian architect Renzo Piano, whose works include the landmark modern-art museum Centre Pompidou in Paris, the \$484-million structure will most likely be the largest

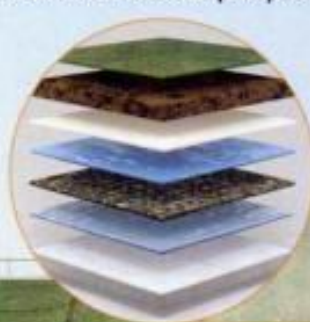
public building ever to qualify for the U.S. Green Building Council's "platinum" LEED (Leadership in Energy and Environmental Design) rating. The designation, so far held by just 70 buildings worldwide, is the highest honor in green construction.

Beneath the roof, museumgoers will find a natural-history museum, a planetarium, a rainforest with free-flying birds, a coral reef inhabited by 4,000 fish, and an aquarium filled with saltwater pumped in from the Pacific Ocean. The most influential display, though, may well be the marriage of the museum's physical design with its educational mission. "It's not about dusty stuffed animals," says execu-

tive director Greg Farrington. "It's about human survival and living in harmony on planet Earth." —KALEE THOMPSON

ROOTED IN SUSTAINABILITY

The living rooftop is tiled with 50,000 biodegradable trays made of coconut husks. Each tray is specially layered to keep plants from slipping down the roof's steep slopes.



short period of time. Roger Kay, the president of computer-industry analysis and consulting firm Endpoint Technologies Associates, which has followed OLPC since its conception, says the nonprofit is "doing OK—not brilliantly, but all right." Although the XO works well for a low-cost device, he says, the execution of the project—everything from failing to

secure buyers in large markets such as China and India, to relying on pro-bono distributors, to its public breakup with Intel—is indicative of OLPC's lack of business experience.

The question is how quickly the organization can learn from its mistakes. Bender remains unfazed by the program's rocky start—"We're looking at getting millions

[of laptops] out in 2008," he says—but in the coming year, the nonprofit will need to recruit a new CTO and fill Intel's vacancy by enlisting a partner wealthy enough to replace the chip maker's millions of dollars in funding. Resolving the Nigerian dispute is also key, because OLPC is prohibited from doing business in that populous market (an

INSIDE THE GREENEST MUSEUM

THE LIVING ROOF

Planted with nine local species, the 2.5-acre roof [A] is the largest swath of native vegetation in San Francisco. It absorbs 98 percent of rainwater, so it doesn't need irrigation.

VENTILATION

Computer modeling of local wind patterns helped architects place the roof's seven mounds to maximize air flow. The valleys



correspond with open areas in the exhibition space below. Cool air blowing through the mounds draws warm interior air up through vents in the ceiling, providing constant circulation that reduces the need for air conditioning.

RETRACTABLE ROOF

Between the planetarium and the rainforest is the museum's central plaza, which opens via a retractable Mylar rain screen.

LIGHTING

Natural light reaches 90 percent of the building's exhibition spaces, minimizing the use of electricity. In addition, the building's

walls and skylights [B] are made of high-performance glass that reflects most heat, while rooftop solar panels supply up to 10 percent of the museum's electricity needs.

MATERIALS

All of the building's structural steel comes from



recycled sources. The concrete contains 30 percent fly ash (a by-product of coal plants), and the structure is insulated with recycled blue jeans.

WATER USE

A pumping station at nearby Ocean Beach sucks water two and a half miles from the Pacific through a buried pipe to a holding tank in the museum's basement, where it is treated, heated, and distributed to the aquarium and coral reef.

PARK-N-PLUG

The museum offers a recharging station for electric and plug-in vehicles.



— The question is what One Laptop Per Child can learn from its mistakes.

estimated 57 million children) until the matter is settled. Additionally, OLPC plans to streamline production, roll out machines that will work in other languages, and continue developing the next version of the XO, which Bender expects will come closer to the \$100

mark when it is released in a few years.

Meanwhile, despite OLPC's turmoil, families are putting the XO to good use. Last March, 20 students in Ban Samkha, a remote, rice-growing village in Thailand, got their hands on the machines—a first for some. They

quickly began to use Google, connect with new friends around the world, and monitor local weather to help alert the landslide-prone village when it's at risk. The Ban Samkha experience serves as a vivid reminder that the OLPC project is worth rooting for.—AMY FELDMAN

The International Space Station

IT WILL BE THE LARGEST, most complex structure that has ever been placed in orbit. When the International Space Station is completed in the year 2003, it will cover an area approximately the same size as two football fields and will sleep seven. Built by a partnership of 16 nations, the station will be a giant laboratory for learning how to live and work in space—in preparation for future manned trips to the moon, Mars, and the universe beyond.



A Walk in the Dark

The tools and techniques of spacewalking missions

BUILDING THE STATION WILL REQUIRE more hours of extra-vehicular activities (EVAs), or spacewalks, than have been done in the past 35 years. During these EVAs, the astronauts will connect umbilicals that carry fluids and electricity between different parts of the station. Tethers and foot restraints will hold the astronauts in place while they work with special tools, sometimes in frigid darkness and sometimes in scorching sunlight. Backpacks regulate the temperature of the astronauts' suits and feature a built-in propulsion system in case of emergency.



Body-restraint tether



Hand-held tool



Experiments are packaged in drawers that slip in and out of lab racks.

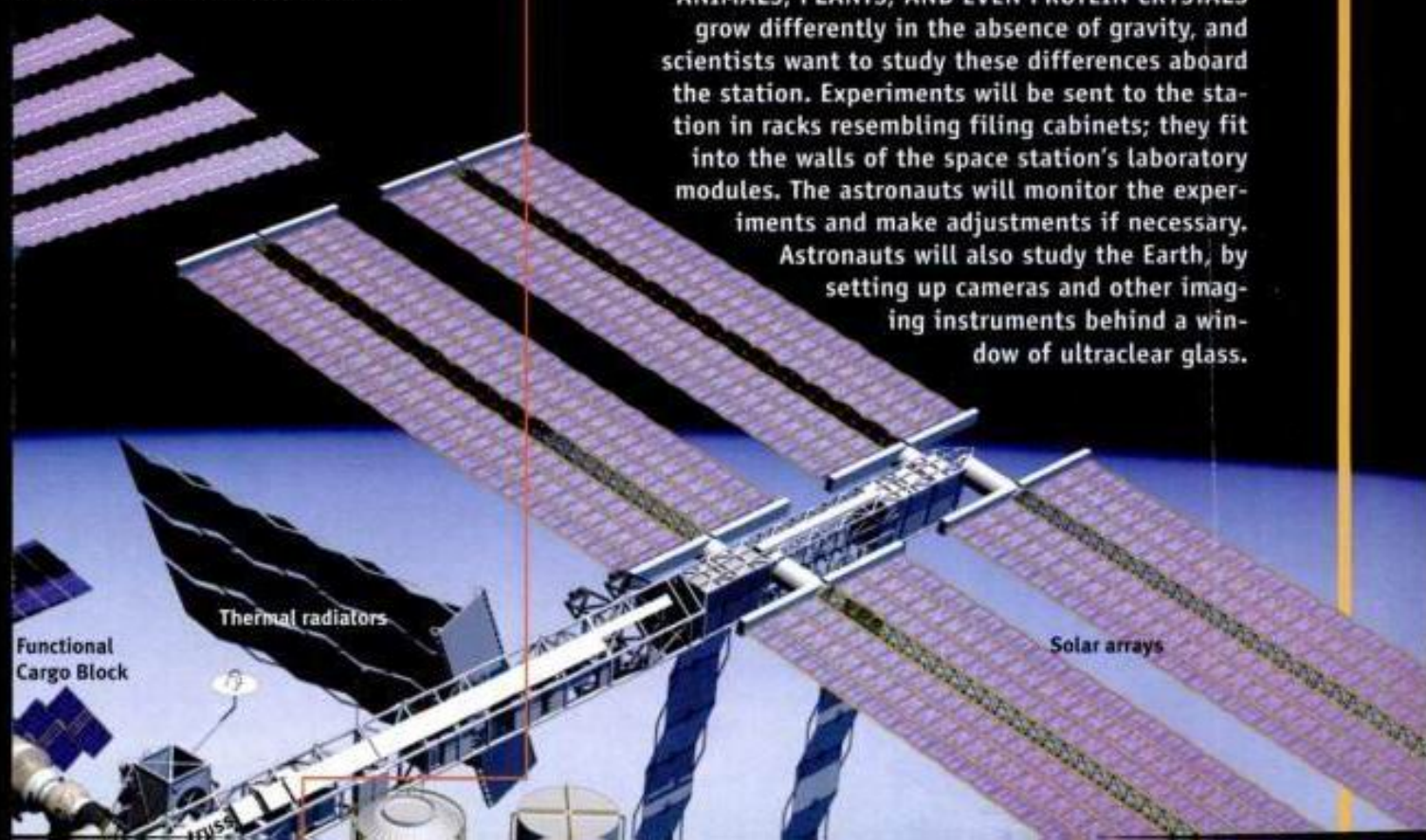


A window provides outside views.

Station Science

Experiments will be conducted inside and outside the station

ANIMALS, PLANTS, AND EVEN PROTEIN CRYSTALS grow differently in the absence of gravity, and scientists want to study these differences aboard the station. Experiments will be sent to the station in racks resembling filing cabinets; they fit into the walls of the space station's laboratory modules. The astronauts will monitor the experiments and make adjustments if necessary. Astronauts will also study the Earth, by setting up cameras and other imaging instruments behind a window of ultraclear glass.



Functional Cargo Block

Thermal radiators

Solar arrays

Life at 220 Miles High

A refrigerator and a shower make life easier in space

FOR THE FIRST FEW YEARS OF the station's construction, the crew will eat, sleep, and go to the bathroom in the Russian Service Module. But when the U.S. Habitation Module is finally added, astronauts will be able to enjoy fresh fruits and vegetables with their TV dinners, courtesy of the first space refrigerator. The Hab Module will also have a shower: Astronauts will smear blobs of water onto their skin, then vacuum themselves with a hose.



Solar arrays

Russian Research Module

Soyuz vehicle



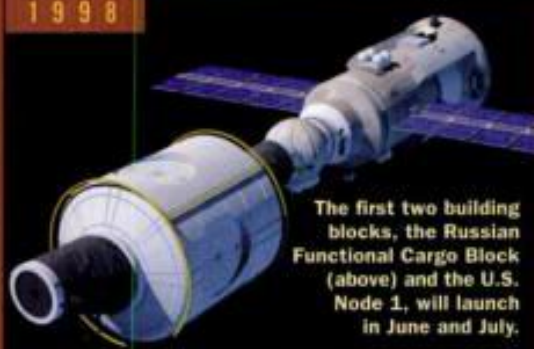
Resupply ships will bring magazines, movies, and candy.

ROOM WITH A VIEW: The last piece to be added to the station, the Habitation Module is a bedroom, bathroom, and kitchen all rolled into one insulated cylinder.

ASSEMBLY STAGES

ASSEMBLY WILL BEGIN THIS SUMMER, but it will take 45 launches of space shuttles and Russian boosters before the ISS is completed. With elements of the station coming from all around the world, many of the pieces will meet for the first time in orbit. Any problems with launch vehicles or individual elements could set back the whole schedule.

1998



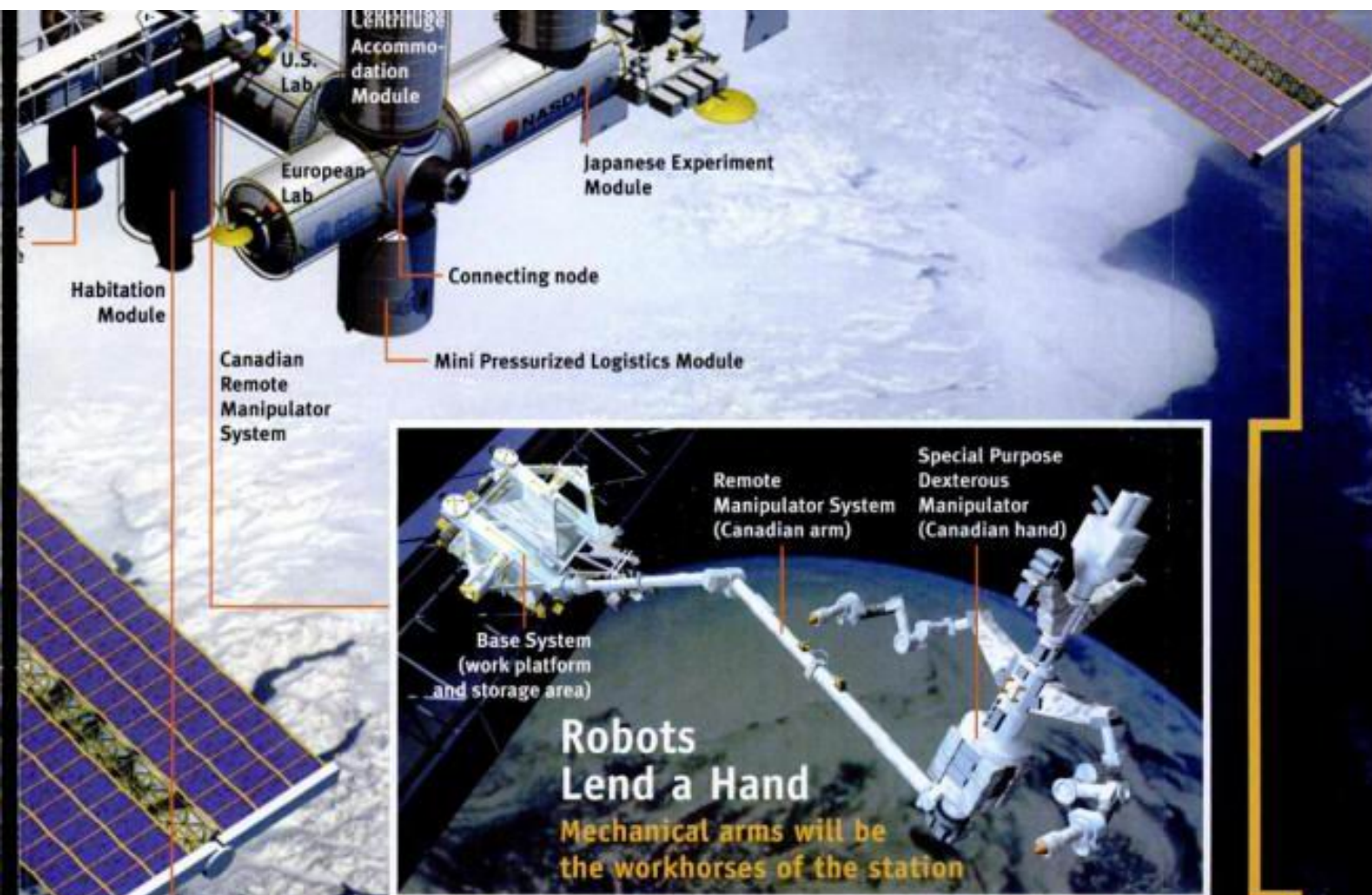
The first two building blocks, the Russian Functional Cargo Block (above) and the U.S. Node 1, will launch in June and July.

1999



By summer's end, the station will have living quarters for a three-person crew, a functional laboratory module, a set of solar arrays, a pair of thermal radiators, and the Canadian robotic arm.





Robots Lend a Hand

Mechanical arms will be the workhorses of the station

MUCH OF THE ASSEMBLY WORK WILL BE DONE with the help of several different kinds of robotic arms. The largest is the 58-foot-long Remote Manipulator System contributed by Canada. This arm moves along rails on the truss work, and can also "walk" from place to place by attaching its free end to a grapple fixture and then releasing the other end. The arm can pick up and use a dexterous hand, which has two arms of its own, for precision tasks.

2001

By this time, the station will have more power from additional solar arrays. The Japanese Experiment Module will also have been delivered and activated.

2003

The ISS should be complete by 2003. Latest additions: Russian and European labs, more solar arrays, and a Habitation Module for the six-person crew.

SOURCES: BOEING, NASA, SPAR AEROSPACE
ILLUSTRATION: BOB SAULS/JOHN FRASSANITO
& ASSOCIATES, DON FOLEY
PHOTOGRAPHY: JOHN B. CARNETT, NASA

check out these Web sites: station.nasa.gov, www.boeing.com

the longest quiet period in the assembly process begins. It will be at least several months before the third station element, the Service Module, is sent up from Baikonur. Using automated docking procedures perfected by the Russians, the Service Module will mate to the FGB port opposite from Node 1.

The Service Module, which is based on technology used in the Mir station's core module, carries the environmental controls and life support system for the entire station. It also has the primary docking port for Russia's Soyuz spacecraft, and the fuel and rockets for both attitude control and station reboost. Reboost is needed periodically to raise the space station's orbit and keep it from reentering Earth's atmosphere.

The Service Module has been the most problematic component of the station, because the Russians have fallen behind schedule in building it. Last year, NASA became so concerned about the delivery of the Service Module that the agency negotiated a \$170 million contract with the Navy to develop an alternative—by modifying a Navy spacecraft built in the early 1980s.

THE CANADIAN ARM

DESIGNED BY Spar Aerospace for the Canadian Space Agency, the Mobile Servicing System is a four-piece robotic tool that will play a key role in assembly and maintenance. Astronauts control it using computers inside the station.

"It was a spinning upper stage to boost shuttle-launched Navy satellites into higher orbits," says Ed Senasack of the Naval Research Laboratory. The spacecraft was abandoned after the Pentagon canceled military use of the shuttle in the wake of the Challenger disaster, and was headed for the scrap heap. "It needed some modifications, but we saw immediately that it could fill in for the Russian Service Module," Senasack recalls.

For now, the Service Module seems to be on track. But the modified Navy hardware, renamed the Interim Control Module, is still under development. If the Russians falter again, the ICM will be ready for flight. If not, the ICM can provide additional storage and boosting capabilities for the space station.

Assuming the Service Module is delivered in time to be launched in December or early 1999, it will be docked to the first two pieces of the station. Its solar wings will then be deployed, doubling the electrical power capacity of the connected units.

Then the business of building a space station gets hectic. A total of 14 shuttle and Soyuz booster missions to the ISS are scheduled for 1999. In January, the shuttle Atlantis will haul up a variety of components to be plugged into Node 1's ports or to be installed inside. Among these are the first truss structure and a third docking port.

The docking port will later be used by a shuttle to offload the first large solar array provided by the United States. It will be attached to the truss in April 1999. Made by Lockheed Martin Missiles & Space, the solar

panels are roughly 100 feet long, the largest ever built for space. A total of 16 panels will eventually be installed, covering about an acre.

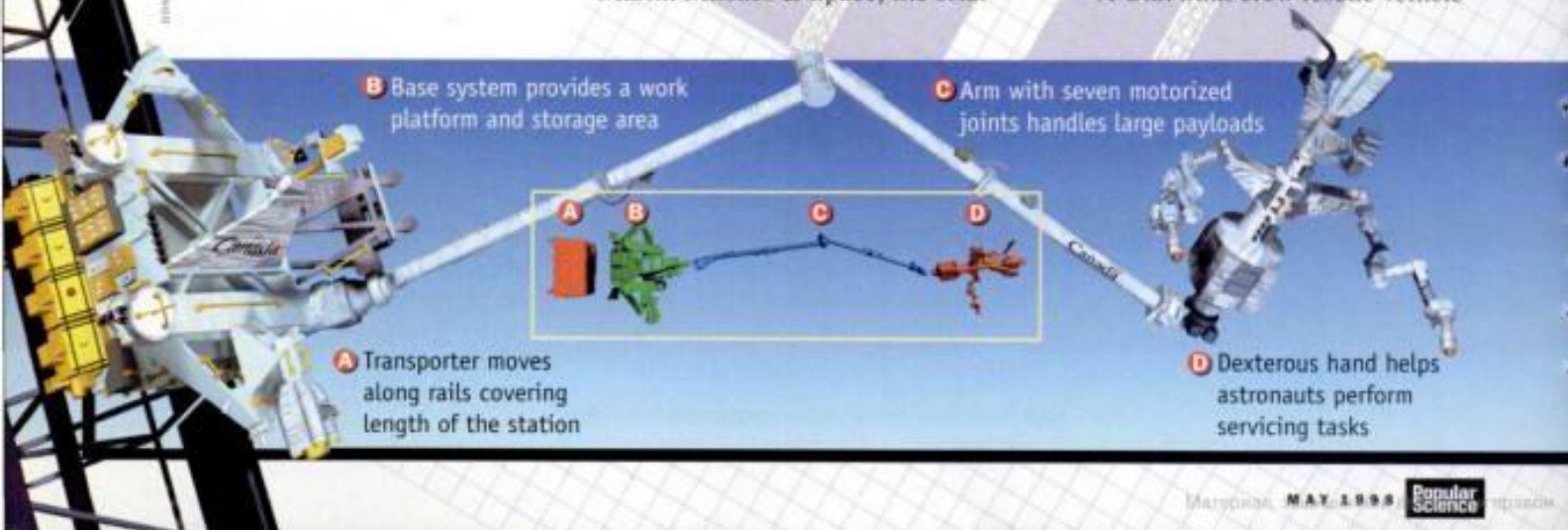
While the U.S. solar arrays will provide the electrical power for life support and scientific experiments aboard the station, Russia will supply the propellant fuel to keep the structure in orbit. "We're the power company, and they're the gas company," explains Brinkley.

But long before all of the solar panels are installed, the ISS will open for business. "The crew will come up immediately," manning the station as soon as Atlantis delivers its load of critical hardware in early 1999, Brinkley says. Barring any major emergencies, the ISS will never again be without human occupants.

The station's first commander will be an American, Navy Captain and former SEAL Bill Shepherd. He and two Russians will ride into orbit aboard a Soyuz spacecraft, which will be docked to the station and serve as an emergency rescue vehicle. Future crews may ride up in a shuttle and come back in a Soyuz, or vice versa.

When the U.S. Laboratory Module is attached in mid-1999, the station will begin looking something like its artists' portraits. The first crew will leave a month later, and a team of one Russian and two Americans will take over, probably for a five-month stay. "We're still staying with our basic agreement with our Russian partners," says Chilton, "that during the assembly phase, we will share time on orbit fifty-fifty for the crews."

A U.S.-built crew-rescue vehicle



will be added to the station in 2003. After that, a six-person crew will occupy the station. Some astronauts may stay as long as 187 days, but there are no plans yet for longer missions. (The official life expectancy of the station itself is 10 years, but it should last much longer.)

"The Russians say that six months is the maximum-efficiency stay in space," Dr. Charles says, "but I think it could really be years. The key is ex-

ercise, and there's probably no time limit for a healthy person up there."

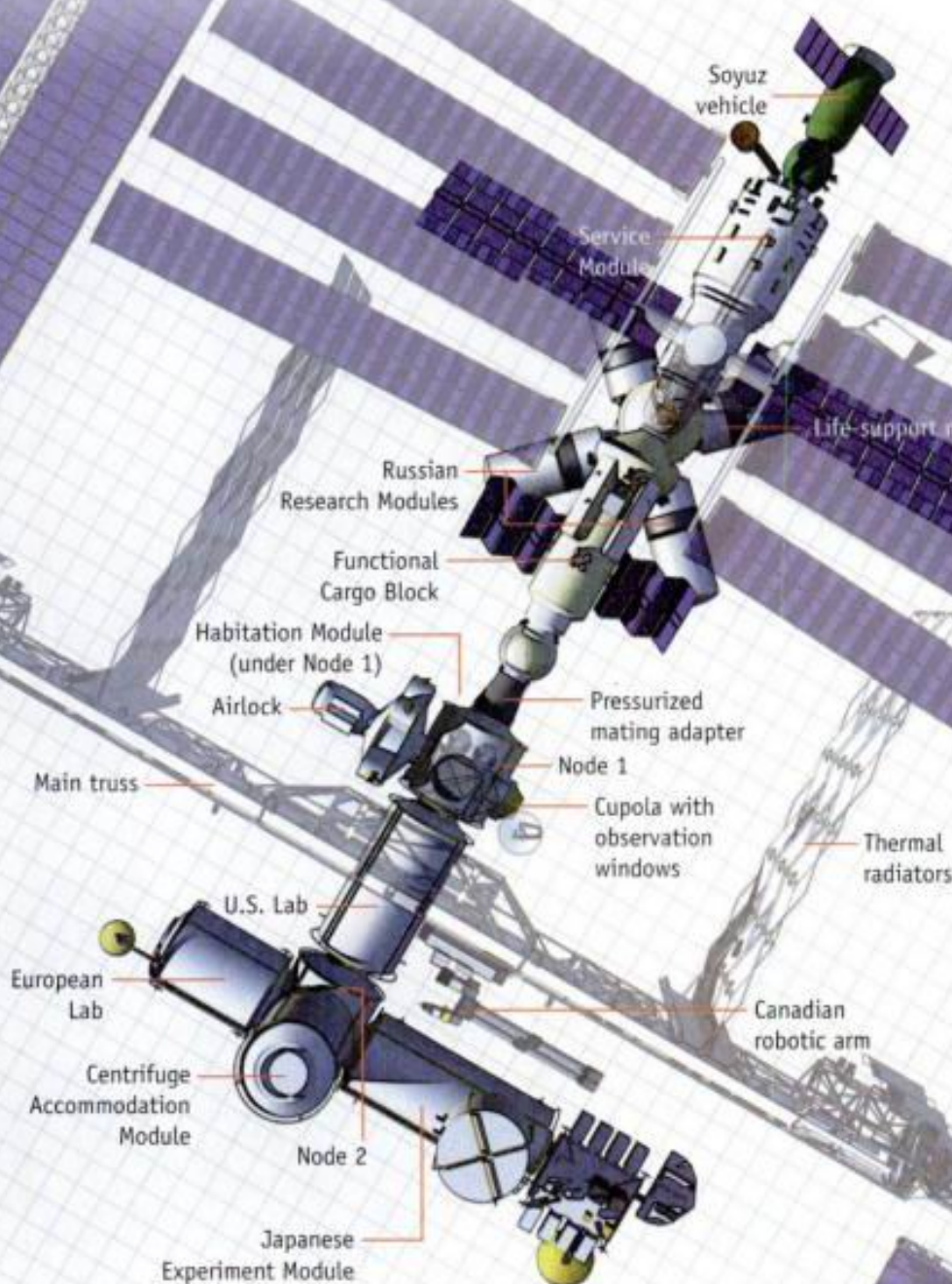
Dr. Al Holland oversees crew psychology at the Johnson Space Center. Working with the Russians and with other nations is bound to create some problems, he thinks. "The big challenges are going to be with the first few crews," he says, "and those will be organizational—setting up shop, solving hardware problems, talking to control centers in Moscow and Houston."

After that, life aboard the ISS should settle into a routine. Holland likens it to a naval deployment. "You're not going up there to drive something," he says. "You're going up to do a job. In the end, a space station is like a ship, not like a shuttle."

But these space sailors are building their own ship from scratch, in the middle of an unforgiving empty ocean. Getting from here to there is going to be a challenge. ♦

YOU ARE HERE

IT'S EASY TO GET LOST in this complex 3-D structure, so we created a blueprint to help you find your way around. Here are locations for the key components that you'll be reading about in the following pages of this special issue.



Second Chance for Biosphere

Nobody lives inside the giant greenhouse now, but the experiment is far from over.



Biosphere's Backyard

BIOSPHERIANS GREW their food in the intensive agriculture area. It will now be partitioned into three identical sections for controlled scientific experiments. For example, the effects of different carbon dioxide levels on plant growth can be compared.

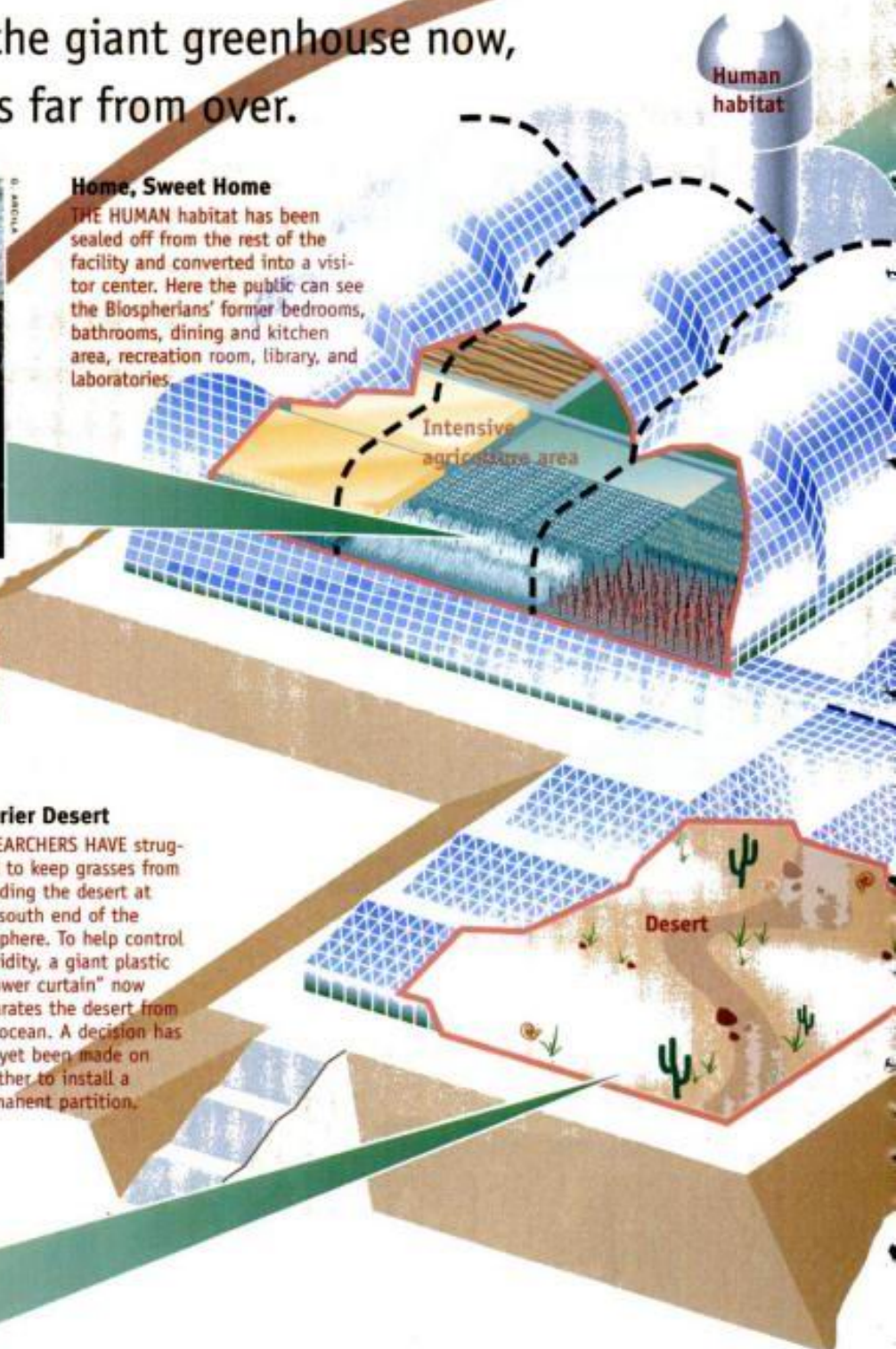


A Drier Desert

RESEARCHERS HAVE struggled to keep grasses from invading the desert at the south end of the Biosphere. To help control humidity, a giant plastic "shower curtain" now separates the desert from the ocean. A decision has not yet been made on whether to install a permanent partition.

Home, Sweet Home

THE HUMAN habitat has been sealed off from the rest of the facility and converted into a visitor center. Here the public can see the Biospherians' former bedrooms, bathrooms, dining and kitchen area, recreation room, library, and laboratories.



INFOGRAPHIC BY GREG MAXSON

AFTER THE HOLOCAUST, cockroaches and ants inherit the world. At least that's what happened inside the gargantuan

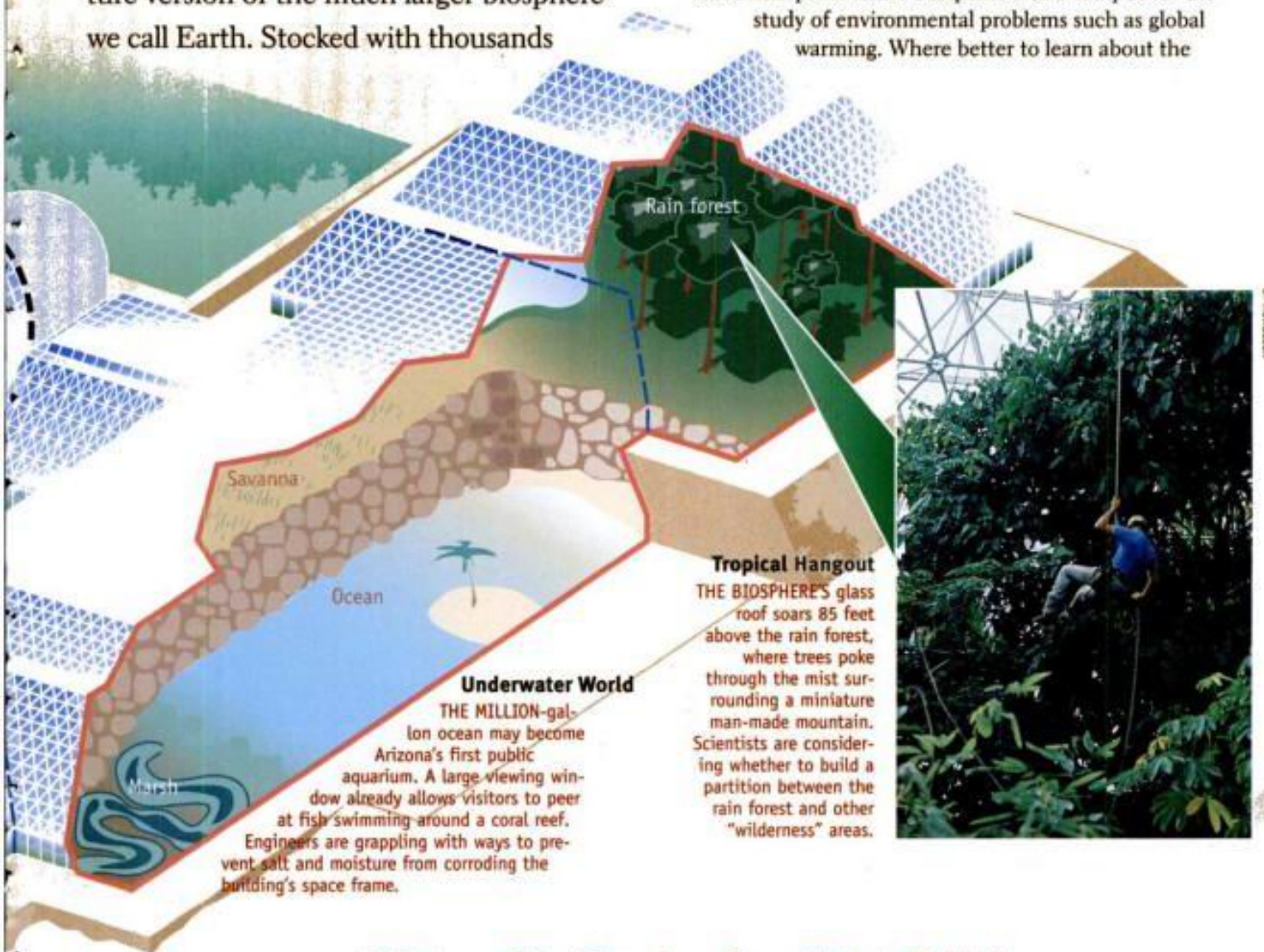
By Dawn Stover greenhouse called Biosphere 2 after an ecological catastrophe brought the ambitious experiment to its knees.

Biosphere 2 was intended to be a miniature version of the much larger biosphere we call Earth. Stocked with thousands

of plants and animals, including eight humans, this land-locked Noah's Ark set sail for a two-year voyage of discovery in 1991. But the project ran aground on bad management and a host of unforeseen environmental disasters, some of which are only now coming to light.

But with an Ivy League institution and a credentialed scientist at the helm, Biosphere 2 is now headed in a new direction. In January 1996, owner Edward P. Bass hired Columbia University to take over management of the beleaguered project. And last October, William C. Harris left a high-level position at the National Science Foundation to become executive director of the Biosphere 2 Center.

Columbia plans to use Biosphere 2 as a campus for the study of environmental problems such as global warming. Where better to learn about the



Rain forest

Savanna

Ocean

Underwater World

THE MILLION-gallon ocean may become Arizona's first public aquarium. A large viewing window already allows visitors to peer at fish swimming around a coral reef. Engineers are grappling with ways to prevent salt and moisture from corroding the building's space frame.

Tropical Hangout

THE BIOSPHERE'S glass roof soars 85 feet above the rain forest, where trees poke through the mist surrounding a miniature man-made mountain. Scientists are considering whether to build a partition between the rain forest and other "wilderness" areas.

A History of the Biosphere from Birth to Rebirth

November 1986



GROUND breaking for the construction of Biosphere 2. Owner Edward P. Bass, a Texas billionaire, eventually spends an estimated \$200 million on design and construction of the project.

September 1991



A CREW of eight Biospherians enters through the airlock for a two-year stay. Just before "closure," engineers install scrubbers to remove excess carbon dioxide from the atmosphere.

August 1992

A SCIENTIFIC advisory committee set up by Bass recommends hiring a scientific director to oversee experiments inside the Biosphere, designing a formal research plan, and sharing experimental data with researchers at other institutions.

Tapping the oceans' vast energy with undersea turbines

Time: the mid-'80's. Place: the swift-moving deep-blue waters of the Florida Current. Tethered to the ocean floor, a huge ducted turbine floats well beneath the surface, its twin rotors lazily spinning in the flow of a massive stream and driving an electric generator. This scene, depicted on our cover, is not fantasy. To explain the evolution of the "Coriolis concept," we asked one of its developers, P. B. S. Lissaman, to write this story. No stranger to readers of PS, he helped design the history-making, man-powered aircraft Gossamer Condor and Gossamer Albatross [PS, Jan. '78 and Dec. '78]. Vice-president of AeroVironment Corp., Dr. Lissaman is an Associate Fellow of the American Institute of Aeronautics and Astronautics. — The Editors

Watermills in the Gulf Stream and other powerful sea currents could produce electricity economically

By P. B. S. LISSAMAN

Anyone who has dealt with the oceans, which cover 60 percent of our globe, cannot avoid being impressed by the mighty and magnificent power of the sea. Constantly in motion—flowing, flooding, ebbing—the oceans are the major receptor of the sun's daily energy flux, processing and storing this virtually limitless source.

Among the greatest reservoirs of solar energy are the ocean gyres, or circulating current systems, generated by the prevailing global winds. The

energy density in these currents is very high, because they are created by a twofold intensification of the direct sunlight: first by the transformation of the sun's heat into wind, then by the transfer of the surface wind stress into the wind-driven currents. This intricate energy transfer is part of the mighty global heat engine. In the Northern Hemisphere, the gyres rotate clockwise, and because of the Earth's spin, are strongest on the western shores of the oceans.

In 1835, Gaspard Gustave de Coriolis published a paper setting up the basic equations describing the distortions of fluid motions due to the Earth's rotation. It is this phenomenon, today called the Coriolis Effect, which intensifies the western portion of the North Atlantic gyre—the Gulf

Continued

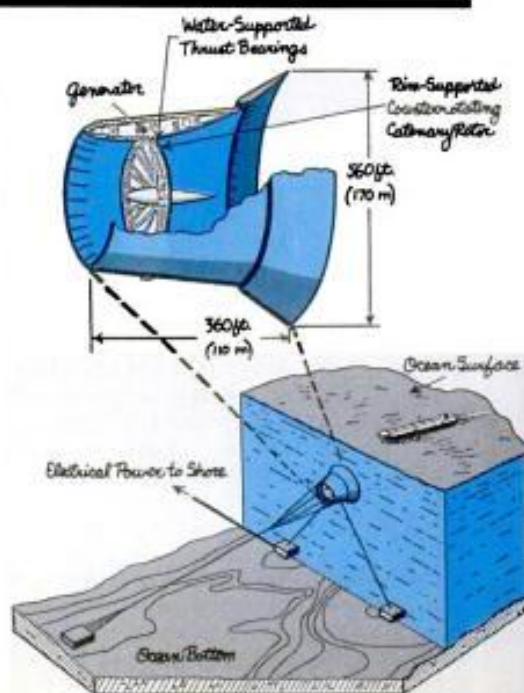
Generating electricity with a Coriolis turbine

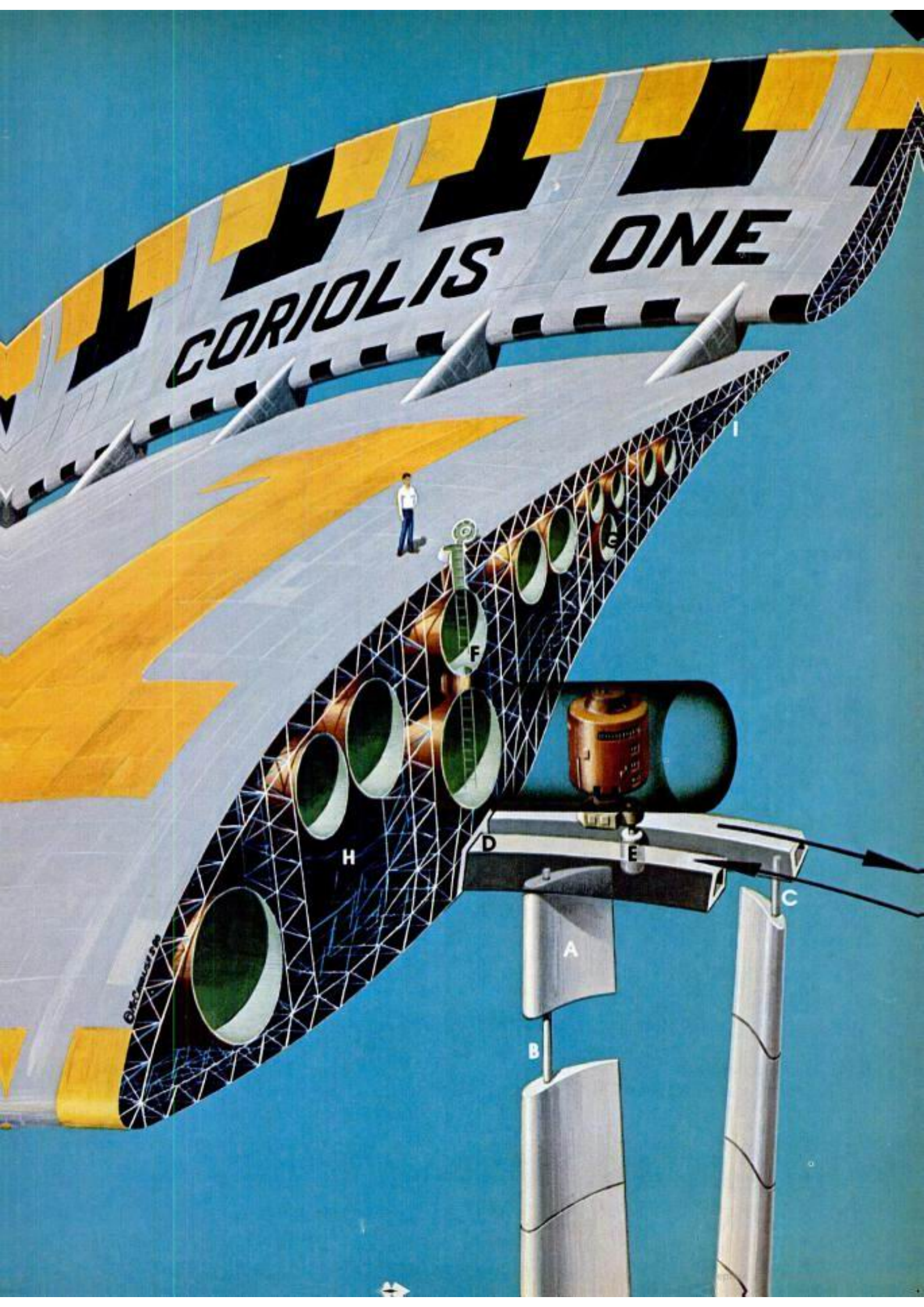
The giant turbine would first be towed in a half-submerged mode to a designated site in the Gulf Stream or other high-energy-density current. Coriolis would then be lowered beneath the surface, by adjusting its buoyancy, and moored to sea anchors on the ocean bottom (see sketch, right). The turbine's general configuration is shown in the sketch and in the detailed cross section (painting, opposite page).

The central mechanism of Coriolis is a two-stage turbine, with two counterrotating rotors. The rotor blades consist of segments (A) threaded along a flexible cable (B) made, perhaps, of Kevlar. In a current stream, the floppy blades assume the shape of a catenary (the curve formed by a rope supported only at the ends). The specially designed shapes of the two sets of segmented blades force them to take opposite-angled orientations with respect to the water flow. Therefore they develop thrust and turn in opposite directions,

driving two counterrotating, circular rims (C), which ride in a water-supported thrust bearing (D). The rims turn friction drives that are connected to electrical generators (E) inside the flared duct shrouding the rotors. The duct also houses control equipment, pressurized access tubes (F), and ballast tanks (G) for altering buoyancy (needed during towing, lowering, and raising the turbine for maintenance). Generally, the hull is flooded (H). The hull structure itself is a space frame truss (I). The hull also provides attachment points for the mooring system. The flared, slotted duct increases the energy of the water flow considerably, and thus augments the power output of the unit.

Electricity generated by the Coriolis turbine is sent to shore over high-voltage DC submarine cables and is inverted there. A unit of the size shown, moored in the Florida Current, could have a rated power output of 83 megawatts.





CORIOLIS

ONE

H

D

A

B

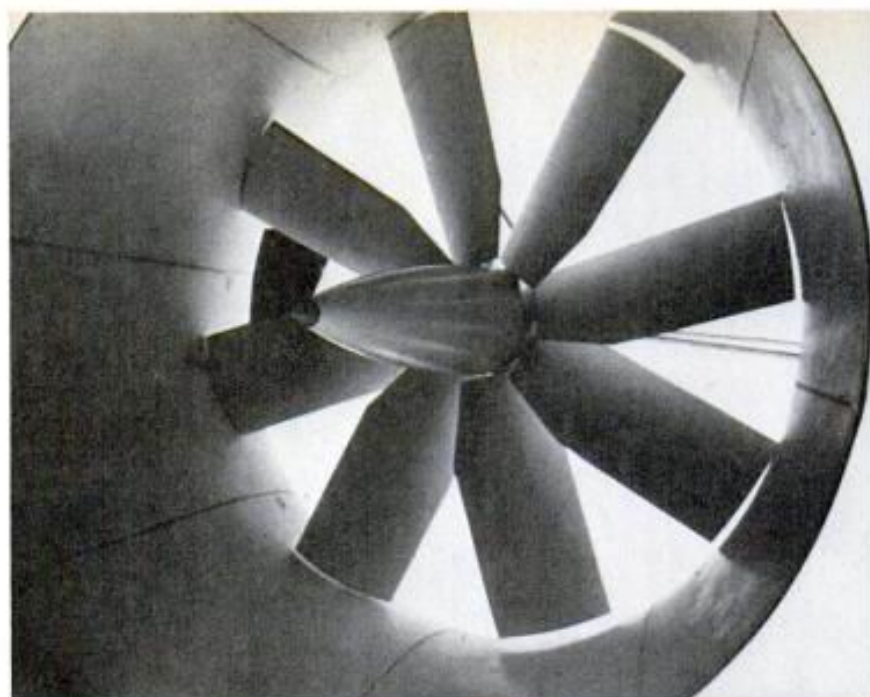
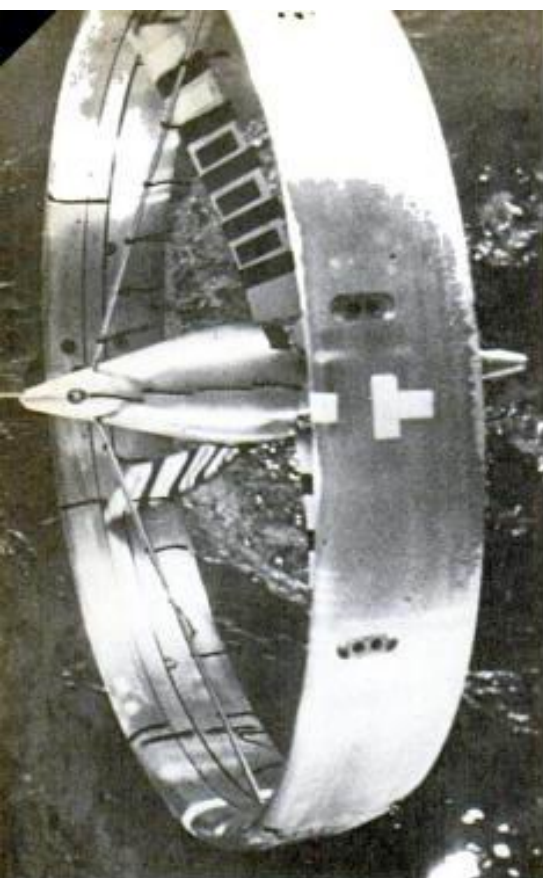
C

E

F

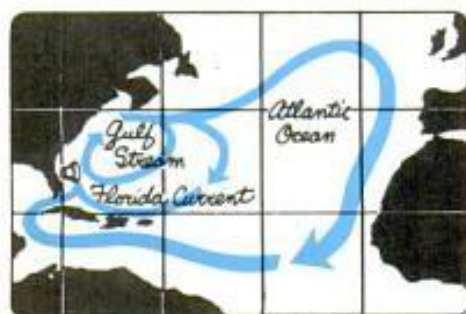
G

I



Coriolis design stages: Small ducted rotor, above, designed by David Thompson, was mounted alongside power boat and tested at various speeds. Results proved

ducting enhanced output. Later, a catenary rotor, left, was tested at David Taylor Naval Ship Research and Development Center, proving stability of design.



Gulf Stream system includes Florida Current, is part of North Atlantic gyre. Twenty miles off Miami Beach, Current contains 50 times more energy than world's rivers.

Stream system—so that the Florida Current, flowing northward only 20 miles (32 km) offshore of Miami Beach, contains 50 times more energy than all the rivers in the world.

For many decades visionaries and technologists have dreamed of using this power. Now the concatenation of oil scarcity, escalating global energy demands, and mounting petro-political instabilities, coupled with the mighty capability of modern engineering, has made this goal appear attainable.

Inspiration on a levee

William J. Mouton is a charismatic personality, a registered civil engineer and professor of architecture at Tulane University in Louisiana. Bill combines his knowledge and love of the old and intricate wrought-iron fabric of the French Quarter of New Orleans with a progressive and pragmatic vision. The result can be seen in his design of slender, steel space

frames for giant contemporary structures, and in his active consulting work in creating innovative concrete and steel towers for the offshore oil industry. A former naval aviator and a dedicated and expert sailplane pilot, Mouton is obsessed with the power of the elements and the harnessing of their natural energy.

In 1973, standing on the levee in New Orleans, watching the roiling, turbulent flow of the flooded Mississippi, he, like many before him, started thinking about the prospects of producing energy from hydroelectric turbines mounted under barge-like platforms moored in the river. But the Big Muddy seemed too small, too capricious. Seeking a more energetic and reliable source, his visions turned to the Gulf Stream, that mighty river in the ocean, always in flood, always streaming northward.

Mouton is a man who views the world on a large scale. He envisaged huge ducted turbines—many of them, each larger than a football stadium—submerged in the North Atlantic.

He could handle the hull and mooring—it was standard marine engineering of the sort embodied in many structures of his already in the Gulf. But he needed a rotor expert. David F. Thompson, President of TM Development, Chester, Pa., was a natural choice to develop the novel rotors for this yet unnamed concept. Dave Thompson is an individual engrossed in new technological ideas and novel ways of using advanced materials. A widely experienced rotor and propeller designer, his corpora-

tion manufactures the only certified lightweight advanced composite turboprop aircraft propellers.

Mouton and Thompson developed the first patentable ideas, and then sought financial backing. This was provided in 1975 by Walter Hajduk, an industrialist of Pennsauken, N.J., who formed Hydro-Energy Associates to finance and direct the program. While Mouton was designing a large ocean turbine unit, of about 560 feet (170 meters) diameter, Thompson built and tested two small three- and 4.5-foot (0.9 and 1.4 m) ducted-rotor units. These were instrumented, mounted alongside a powerboat and tested at a range of speeds. The turbine went round. The output was measured. The duct did provide amplification of the energy flux. The system worked. Design of the large unit progressed.

This first 560-foot unit was designed to develop a power of about 83 megawatts in a current speed of about 4.5 knots (2.3 meters per second). First studies of the energy of the Florida Current had indicated there was a central core, about 16 miles (26 km) in lateral width and extending from the surface down to about 750 feet (230 m), where the annual average speed (the energy speed) was about 3.7 knots (1.9 m/s). It varied from a peak of about 4.5 knots in midsummer to a winter low of about 2.9 knots. The summer high output matches quite well with normal Florida power demands, which tend to be higher during the hot months.

The mechanical and hydrodynamic

APRIL 1972 60 CENTS

Popular Science

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and cut pollution



How you'll fly at almost the speed of sound in NASA's New Mach 1 Airliner



A craft with a radical new wing and a striking wasp waist will give you a ride 100 miles an hour faster than any passenger plane you can board today

By DR. WERNHER von BRAUN

NASA Deputy Associate Administrator
PS Consulting Editor on Space

In the late Seventies you'll ride an airliner of a new breed through the skies.

It will fly you about 100 miles an hour faster than today's passenger planes. It will offer you a smoother and quieter ride. On top of these advantages, your fare should be reasonable, because the new craft will be more economical to operate than any airliner in use today.

Good-neighborly features of the advanced airplane will appeal to others besides passengers and operators. Its engines will be smokeless. Outside, as well as in, its sound will be hushed.

NASA, which has pioneered this radical airliner, calls it the Advanced Technology Transport—ATT for short. It also goes by the name of

the Mach 1 airliner, because it will cruise at almost Mach 1—the speed of sound or about 660 mph, at cruising altitudes of 35,000 to 45,000 feet.

The Advanced Technology Transport will be "boomless." Its speed will not quite suffice to cause the objectionable sonic boom that supersonic aircraft create as they pass through the speed of sound. But it will far outpace today's airliners. The Boeing 707, for example, lumbers along at Mach 0.84—about 550 mph in layman's language. ATTs will speed as fast as Mach 0.98, or about 650 mph.

A whole family of ATTs, from 200-passenger airliners of transcontinental range up to 400-passenger transocean versions, is foreshadowed in current studies by NASA and by leading airplane and engine builders under NASA contract. At Mach 0.98 they will clip nearly an hour from a New York-to-San Francisco flight; up to two hours from an ocean crossing.

Higher speed without using more fuel, giving the ATT the economy of more miles per gallon of fuel, comes from two major breakthroughs:

The new supercritical wing. In July 1965, a confidential report announced the discovery of a wonder-working new wing shape, called the "supercritical wing," by Dr. Richard T. Whitcomb of NASA's Langley Research Center.

As a conventional airplane wing approaches the speed of sound, the airflow past its curved upper surface locally becomes supersonic, and a

Conspicuous wasp waist, new to passenger



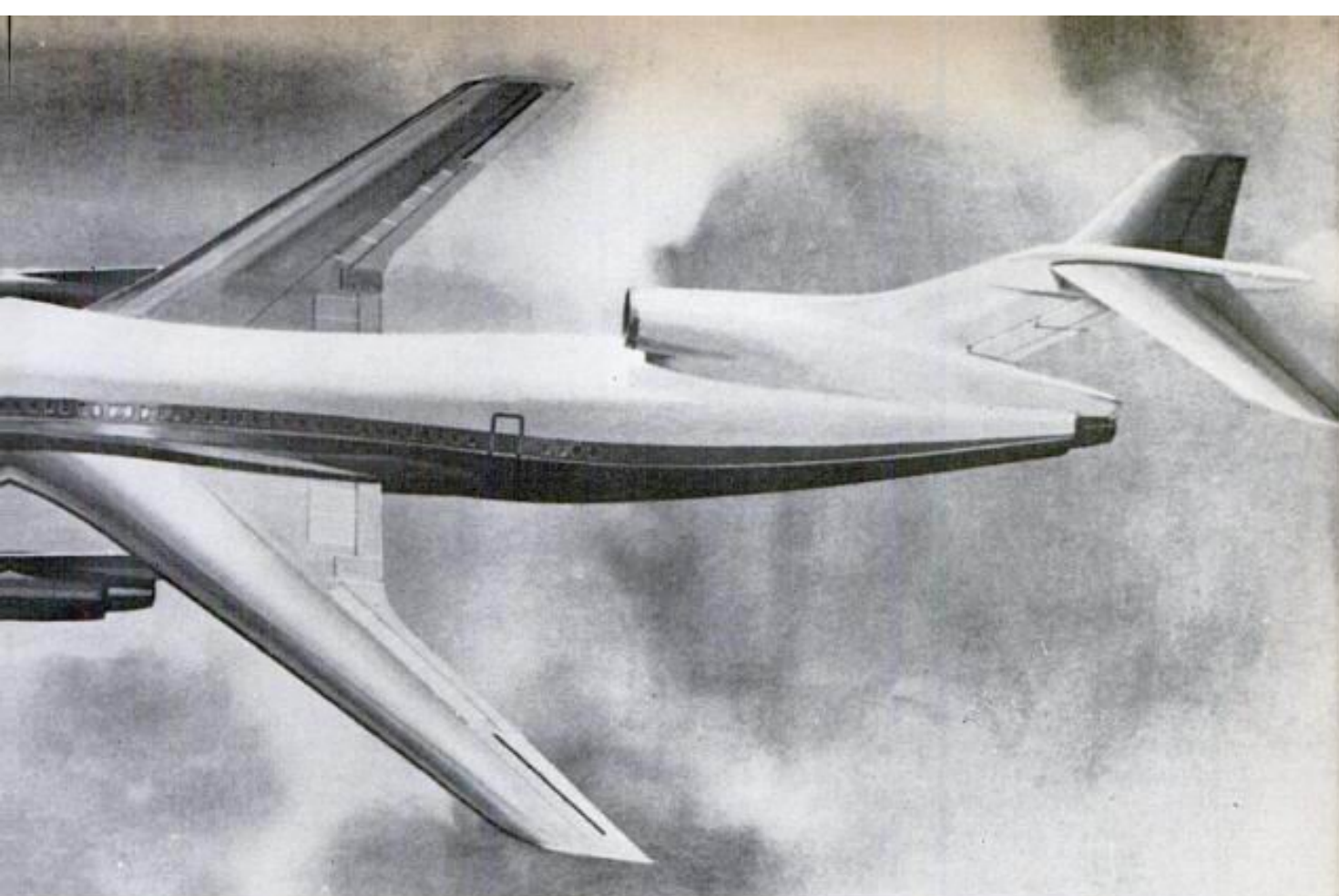
Projected family of Mach 1 airliners may include 400-passenger transocean craft, ex-

shock wave begins to develop there. Beyond this "critical" point, as it is called, there is a precipitous rise in air drag and the engine power required to overcome it; moreover, buffeting fatigues structures and causes discomfort for passengers.

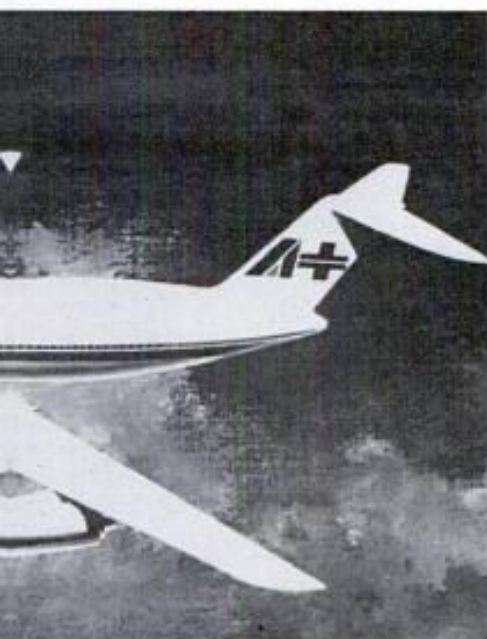
The novel flat-top shape of the NASA supercritical wing delays the onset of these effects. Wind-tunnel tests, between 1965 and 1970, indicated that it promised speeds exceed-



Dr. Richard T. Whitcomb, who pioneered supercritical wing and wasp-waist concepts, views model of new wing on an F-8.



aircraft, is striking feature of NASA's Mach 1 plane. The 200-passenger transcontinental version above is envisioned by Boeing.



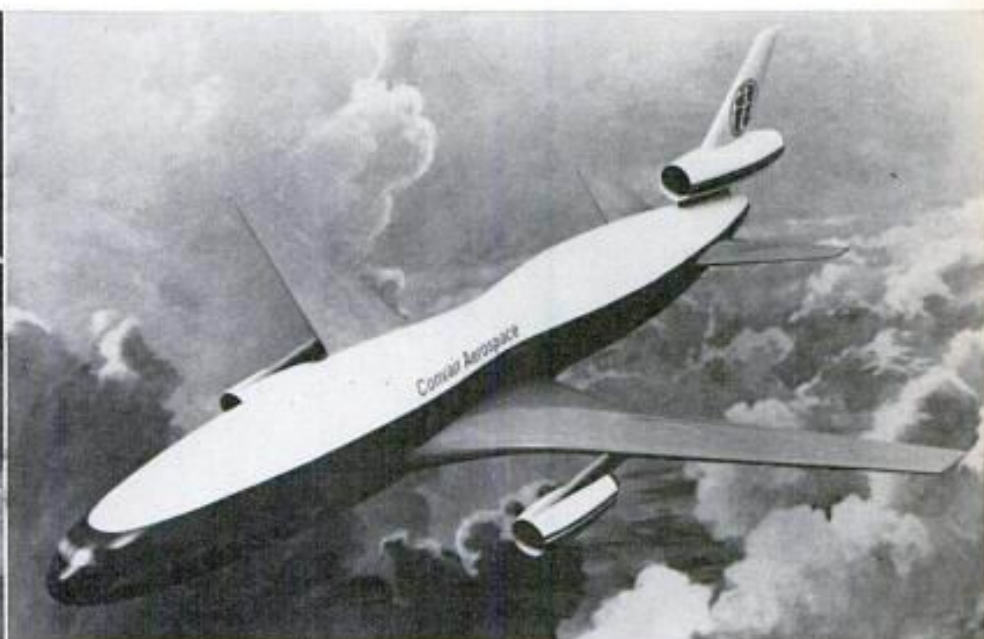
emplified by this Lockheed concept, with a range of more than 5,700 statute miles.

ing Mach 0.95 before the drag rise and buffeting began.

Finally the wraps came off, and in early 1971, the new wing's predicted performance was verified in flight tests with a modified F-8 airplane.

To build an airliner that could take full advantage of the new wing, another major discovery—already contributed by the same researcher, Dr. Whitcomb—had to be applied:

The wasp waist. Most conspicuous



Alternative Mach 1 airliner is the design of General Dynamics' Convair Division; a 200-

passenger craft with coast-to-coast range of more than 3,400 miles.

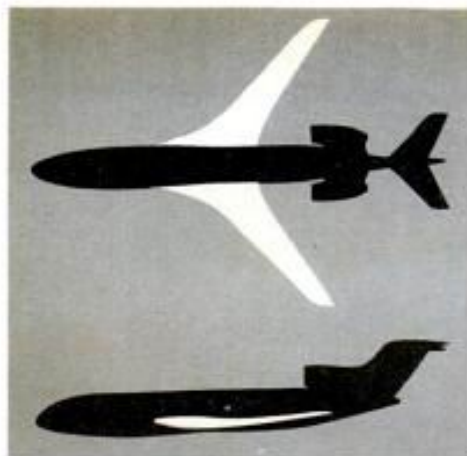
innovation of the ATR will be its other breakthrough, the wasp-waist or "Coke-bottle" shape of its fuselage. Like the newer supercritical wing, the wasp waist plays a key role in reducing air drag.

The pinched-in shape stems from a drag-reducing Area Rule that made big aeronautical news when its discovery by Whitcomb was released from military secrecy in 1955. In its simplest or "transonic" original ver-

sion, the Area Rule works like this:

Take one of our present-day airliners such as the Boeing 707. Determine its drag-producing areas from nose to tail by taking slices, salami fashion, at one-foot intervals. You'll find the cross-sectional area increases smoothly up to where you get to the full diameter of the cylindrical body. Here it levels off.

But as your wandering salami knife strikes the engine intakes and the



New supercritical wing, an innovation to be incorporated in the coming Mach 1 airliner, is shown above being installed for flight trials on a modified Navy F-8 jet plane at

NASA's Flight Research Center, Edwards, Calif. Drawings at left reveal novel shape of the drag-reducing "flat-top" wing as viewed from top and side.

wing root, the drag-producing cross section suddenly shoots up again. On a graph of step-by-step areas, it forms an ugly bump. This bump is by no means desirable for a Mach 0.84 plane like the Boeing 707. For a Mach 0.98 transport it would be disastrous. To keep the drag at that speed within acceptable limits, that bump has to be reduced or eliminated.

The solution is to tighten the belt of the airplane's body, enough to offset the excess cross-sectional area of wings and engine nacelles. And what you get is the wasp waist.

The first wasp-waisted aircraft were Air Force and Navy fighters of 1954. The B-58 Hustler bomber of 1956 was another example. While many later supersonic aircraft look as if their designers had never heard of the innovation, the reason is simple:

Benefits of the original Area Rule's wasp-waist shape are limited to the transonic range of speed—about Mach 0.9 to Mach 1.2. For faster craft there now are more-complex "supersonic" forms of area-ruling, which do not lead to a prominent wasp waist, but to subtler refinements of shaping. The wasp waist, however, remains ideally advantageous for a plane that lingers

near Mach 1. The ATT, first passenger plane that just fits this description, will therefore have it.

This "waisting" raises another question. A very convenient way of adapting airliners of the same generic breed to airlines' widely differing requirements is the method called *stretching*.

By adding constant-diameter body sections fore and aft of the wing, higher-capacity models of a current transport can be spun out of the original airplane with relative ease. We all have seen the stretched DC-8s and the stretched Boeing 727s.

The capability to stretch a basic airplane design will be as important for the breed of Mach 1 airliners as it is for today's birds. Obviously, with a carefully sculptured area-ruled Mach 1 transport, thorough wind-tunnel studies must precede and support design stretchouts to avoid unacceptable bumps.

Showcase of advanced features. The ATT aims at much more than higher cruising speed. It will be a showcase of the most advanced technology of all kinds that can be crammed into an airplane. There are a number of innovations it will incorporate.

- Engines will not smoke at any power setting. Carbon monoxide and unburned hydrocarbons in the exhaust will be greatly reduced, diminishing air pollution.

- Noise will be lowered far below stringent Federal standards for new aircraft, without a noticeable effect on operating cost. Further dramatic quieting, by improved engine design and acoustic treatment, looks possible with only a modest increase in operating cost.

In a world extremely sensitive to the words "pollution" and "environment," these competitive advantages alone may often be decisive.

- Composite materials—like fiberglass in principle, but using novel recipes such as boron fibers embedded in a plastic matrix—will find extensive use and will reduce structural weight by 10 percent or more.

- A technique called "fly-by-wire," which has become a must in manned space flight, will make airplane controls responsive to an ATT pilot's gentle touch. By way of a computer, his pedal and yoke deflections go to power-steering actuators that move the airplane's control surfaces. The same computer accepts additional command signals from instruments such as an angle-of-attack meter, an airspeed indicator, an altimeter, and an accelerometer.

Extensive flight testing has shown that the more-elastic response of fly-by-wire to gusts and turbulence will offer you a smoother ride. It also extends the "fatigue life," and thus the revenue-producing life, of the entire airplane structure.

- At terminal airports, steep climb-outs and landing approaches will greatly reduce the ground area affected by low overflights—a desirable goal, even with drastically reduced engine noise, in densely populated localities. Today an airplane making an instrument landing, under conditions of low ceiling and limited horizontal visibility, must follow the shallow 2½-degree glide slope provided by standard sys-

[Continued on page 132]



Airborne on new wing, F-8 confirms promise it showed in wind-tunnel tests. For more

experiments, addition of side fairings will give test plane a wasp waist.

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Popular Science

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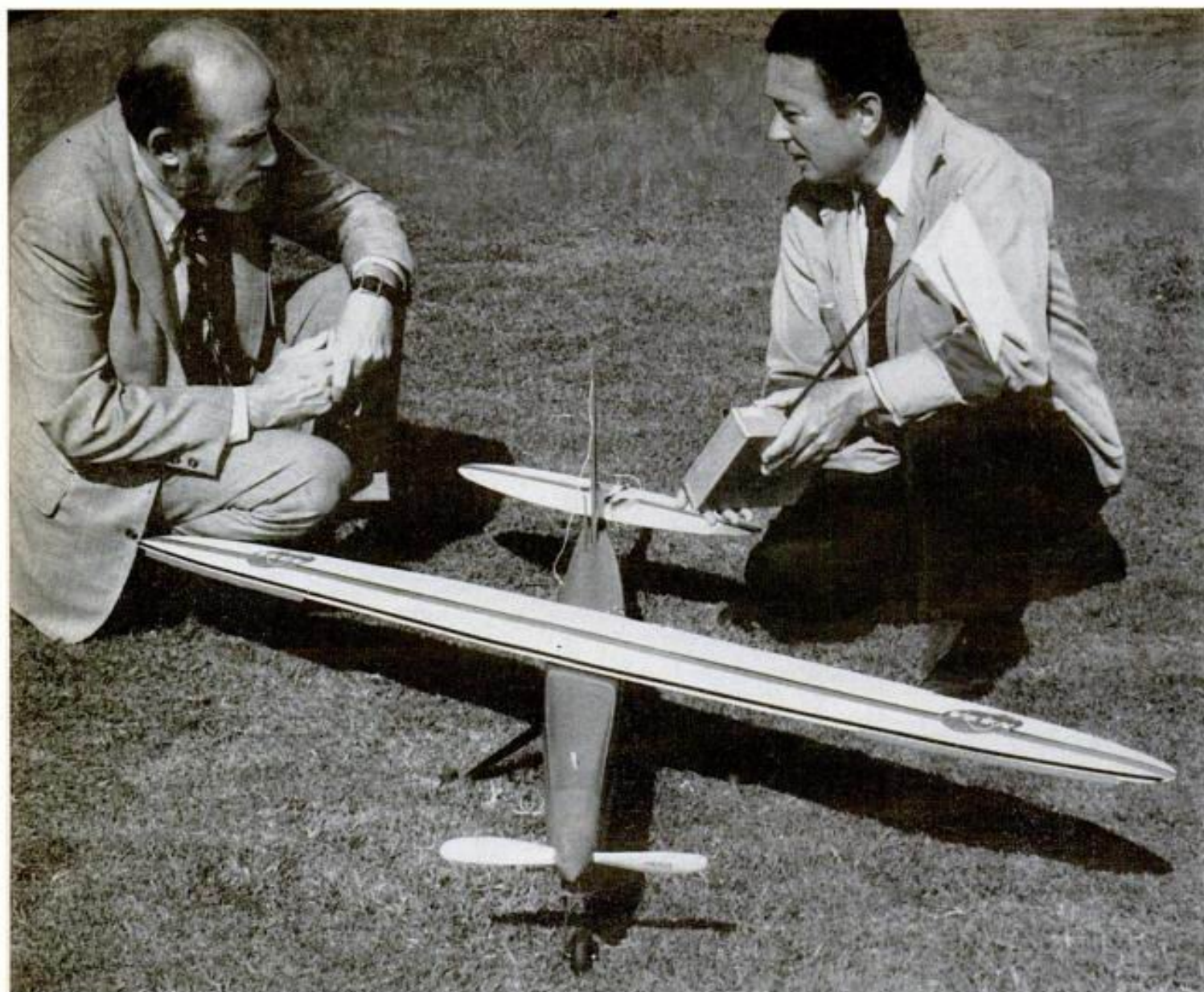
How You Can
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**NASA's Startling SST
"FLYING SCISSORS" JETLINER
Cuts the Sonic Boom**

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Designer Robert Jones (right) shows author how he pivots wing and tail of plane's model with conventional radio transmitter.

NASA'S STARTLING SST:

"Flying Scissors" Jetliner

Present SST proposals are too noisy, expensive, and insulting to the environment. This slew-wing design could be the solution

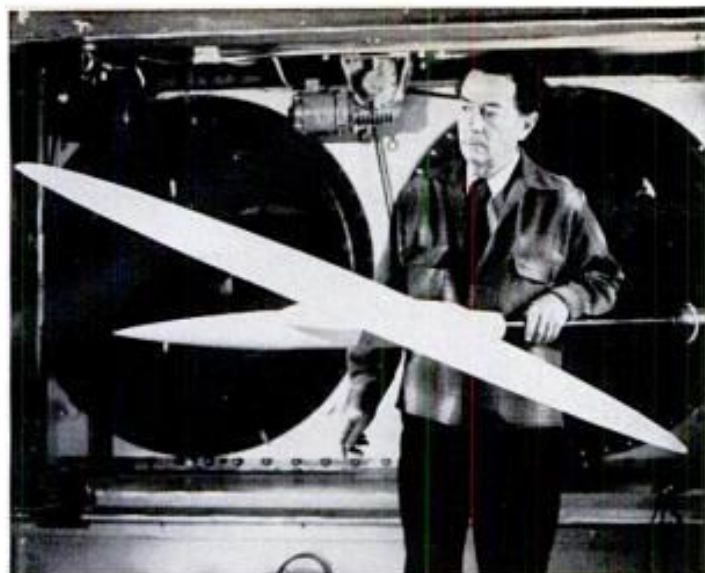
You and I have been promised a workable supersonic transport for many years. It would not only carry passengers at supersonic speeds, but would also be safe and efficient. More important, it wouldn't be a noisy nuisance and a threat to our environment. So far, no dice.

So there I was once again at one of NASA's fantastic supersonic research laboratories on the West Coast and being told once again that I was to see a radical change in basic airplane design.

I looked at the demonstration model and found it hard to believe. At first sight, it looks like a conventional gas-

powered, free-flight, radio-controlled model airplane. But when you press a control on a small radio transmitter, there is a slight whine and the wing starts to pivot on its middle. The same thing happens to the single-piece stabilizer (elevator). The left side swings forward and the right swings back. The wing actually swivels up to 60 degrees from the usual position, and stops at any angle in between.

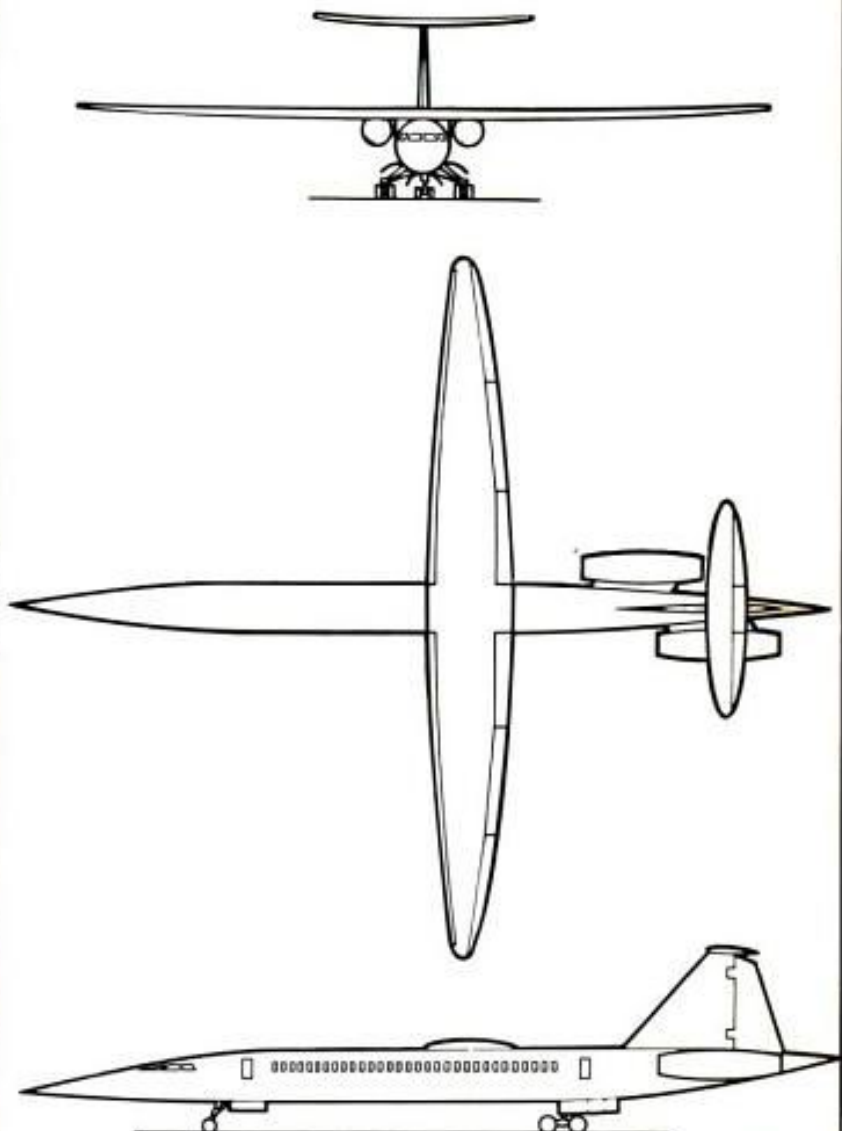
Supersonic—without audible boom. What looks at first like a hare-brained idea now seems to offer a solution to many of the problems the first U.S. supersonic airliner must overcome. Possibly most important, this design promises to fly supersonically—at Mach 1.2—over land without making a sonic boom audible on the ground. That's slower than the Mach 2 Concorde and the original 1800-mph Boeing and Lockheed SST proposals, a theoretical disadvantage. But the low-drag profile of this new concept's "skew wing" will result in greater economies on a cost-per-passenger-mile basis than for the other



Jones displays one of several elliptical test wings he "flew" in NASA's wind tunnel at Ames at speeds up to Mach 1.4. Tests also flew model at takeoff and landing speeds with wing straight.



Supercritical airfoil that lets conventional jets fly longer distances with less fuel was also used in wind-tunnel tests. Wing was designed by Richard Whitcomb at NASA's Langley, Va., center.



Three views of the slightly supersonic jet shows wing and tail at right angles for takeoffs and landings. Two jet engines in the tail remain antisymmetric during all phases of flight.

Cuts the Sonic Boom

By BEN KOCIVAR
PS Consulting Editor, Flying

SSTs. And because it uses less fuel, it will be less polluting than other SSTs.

With the wings at an oblique angle, my past experience with models and real planes tells me the bird simply can't fly. I think such a concept could possibly go ape before going supersonic. How wrong I am. Fly, it does. Taking off with the wings straight, the model zooms at about 100 mph with its one-hp engine. Then, wing askew, it loops, rolls, and finally, with wing straight again, it comes in for a controlled landing.

The balsa prop-driven model is not supersonic, of course. But computer research and wind-tunnel tests at 900 mph with meticulously machined steel wings have already proven that the oblique-wing concept works.

The man who designed this "flying scissors" has pretty good credentials. He is Dr. R. T. Jones, a senior scientist at NASA's Ames Research Center, just south of San Francisco.

Bob Jones is a mild-mannered, soft-spoken, slightly

built scientist, whose research played a major part in developing swept-wing supersonic planes 25 years ago. He had only one year of college before he got a job designing airplanes for a small company. Then the Great Depression hit; he describes himself as the "first unemployed aerospace engineer."

He got a job as an elevator operator in the House Office Building in Washington, D.C., and from there went to Langley, Va., with NACA (which preceded NASA). He stayed with the aerospace-research agency until 1962, then went to work for Avco in Boston and applied his air-flow expertise to blood-turbulence problems for an artificial-heart research program [PS, Dec. 1965]. He returned to NASA eight years later.

Idea without precedent. Oddly enough, he told me, he first discussed his antisymmetric wing in 1945. "It seemed so strange I didn't have the courage to propose it," he wryly admits. Man has always looked to the bi-

Continued

Fuel-saving aircraft

New technology promises more passenger miles per gallon

Many-faceted NASA program to boost airliner efficiency includes such innovations as winglets, flexible skins, and laminar flow control

By WERNHER von BRAUN
PS Consulting Editor, Space

During the 1990's, a sleek new generation of wide-body airliners that use half the fuel guzzled by today's jumbo jets should go into service. As you walk aboard these new aircraft, you'll see some of the innovations responsible for this remarkable fuel saving.

The wings, for example, will be strikingly long and narrow to supply extra lift. A flat-topped supercritical wing planned for NASA's Mach-1 airliner [PS, April '72] makes this glider-like design feasible. Each wing will be tipped with small airfoils called winglets. These short, slanted surfaces, similar to the wing tips on buzzards and other soaring birds, will provide extra thrust.

Look closely at the wings and you may notice a porous or slotted surface instead of the mirror smoothness on today's aircraft. Turbulent air just above wing surfaces will be sucked in through these holes. Part of the aircraft body may even have a *flexible* surface—a compliant fuselage surface that might help future airliners knife through the air much as a porpoise's flexible skin enables it to speed through water.

Lightweight, super-tough composites—fibers of graphite or boron embedded in epoxy resin [PS,

April '75]—will eliminate many metal aircraft parts, shaving off fuel-wasting weight. Advanced engines, operating at fuel-efficient higher temperatures, will power your plane. Sensors that detect turbulence will smooth your ride and save fuel by feeding signals to computers that in turn will activate aircraft-control surfaces.

Slowing down

Until recently, the time-honored formula for changes in airliner design has been simple: Any airliner had to be faster and more comfortable than its predecessor. But the blockage of commercial overland supersonic flights, an Arab oil embargo, and a tripling of overseas jet fuel prices have clearly signaled that fuel efficiency, not speed, is the name of the game.

The appearance of future aircraft should reflect this change of attitude. The new breed of fuel-efficient airliners will probably look much like today's planes, and most of them are likely to be flying along at kerosene-saving speeds of Mach 0.8 (about 600 mph). The needle-nose supersonic designs have proven to be wasteful of fuel.

Last year, nudged by aviation-minded senators Frank Moss and Barry Goldwater, NASA consulted 200 industry and government experts to prepare a technology-development program for new fuel-saving aircraft. The NASA task force has reported that moderate gains in fuel economy are possible within a few years. Some fuel-saving improvements could even be retrofitted on existing airliners. But other fuel-saving gains, for use 10 to 15 years from now, will require

new materials and technology, plus extensive studies in wind tunnels. Here's a rundown of the more important changes you can expect.

Laminar flow control

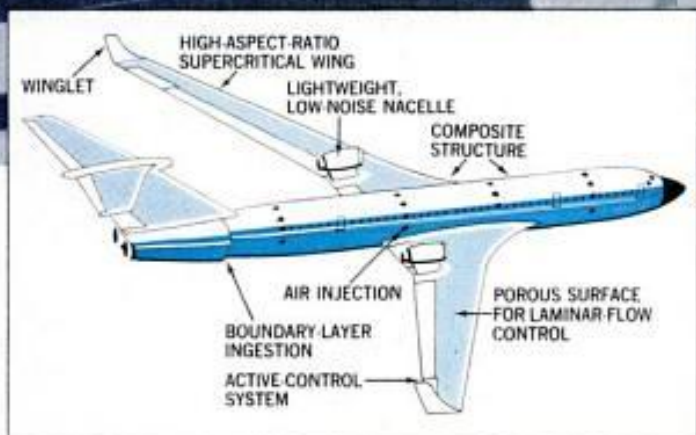
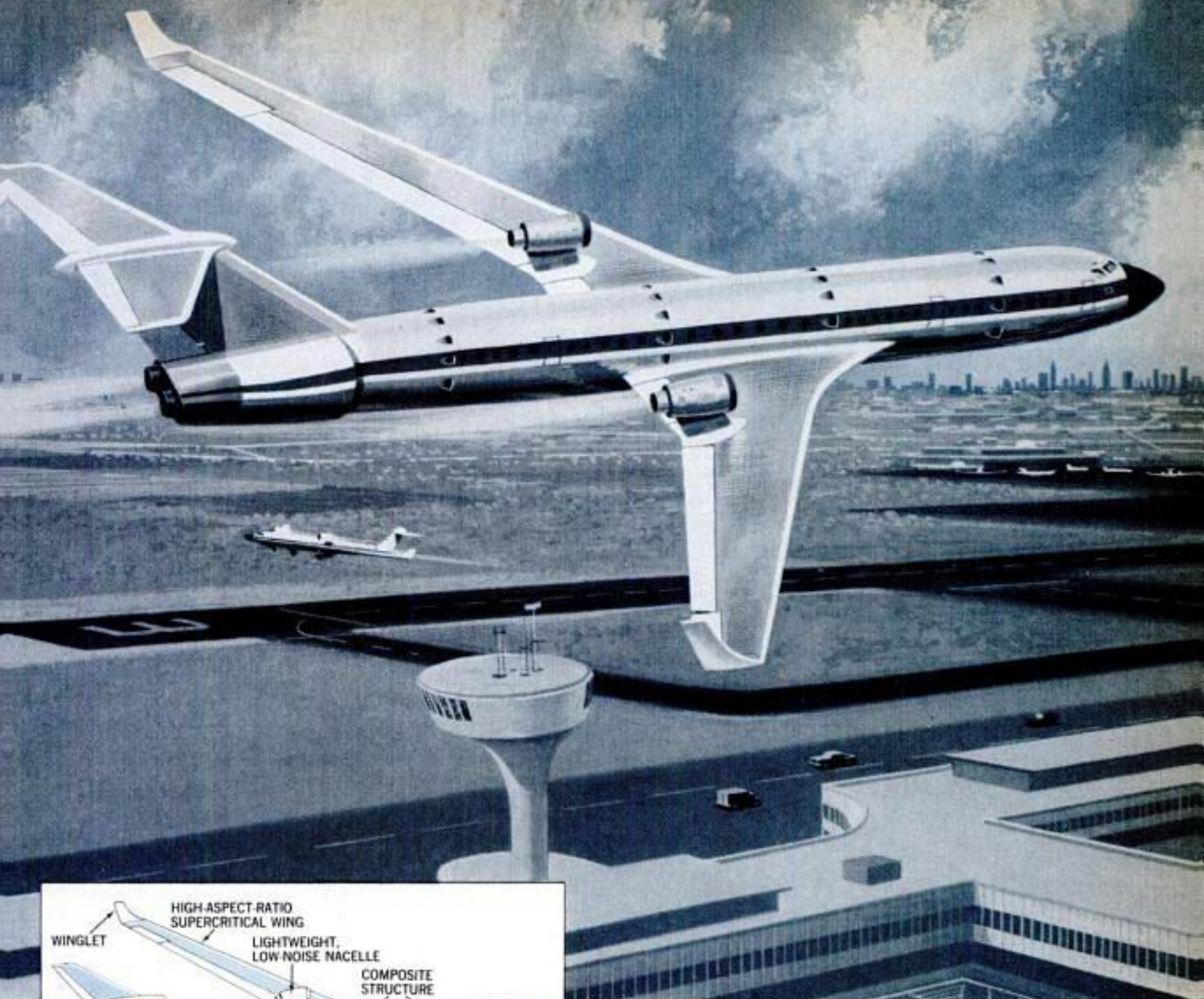
One of these more advanced proposals, laminar flow control (LFC), promises dramatic fuel savings. By smoothing airflow over the plane's skin, LFC could eliminate roughly half the air drag on a subsonic airliner. Normally, the so-called boundary layer just above an aircraft's skin is filled with turbulent eddies of air. These eddies create air friction, making the engines work harder.

Ten years ago, an experimental USAF X-21A demonstrated that by sucking air into its wings through numerous small slots, airflow in the boundary layer became eddy-free or "laminar." The laminar-flow-control project did not proceed beyond the demonstration stage, in part because of unsuitable air-pumping equipment. Another problem was the partial blockage of suction slots by insects. LFC experience under conditions of icing and severe rain is still limited, but these may cause problems, too.

Aviation engineers expect to solve these problems: Jet-engine compressors have a tremendous suction capability and are an obvious pumping source to achieve laminar surfaces; lightweight panels of porous composite materials may be used for these surfaces, and might alleviate the problems caused by adverse weather.

NASA estimates that a whopping 20- to 40-percent fuel saving is possible on LFC-equipped airliners,

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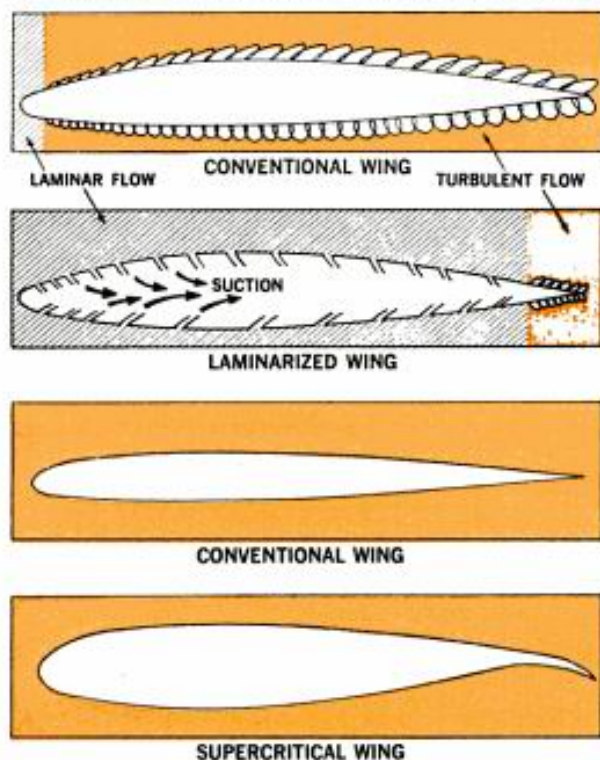


Glider-like wings will give fuel-saving extra lift to this 1990's jet, based on a NASA model. Other fuel-efficiency boosters: laminar-flow-control systems that suck in turbulent air on wings and tail, or blast it away from fuselage; light, stronger-than-steel composite materials that reduce aircraft weight.

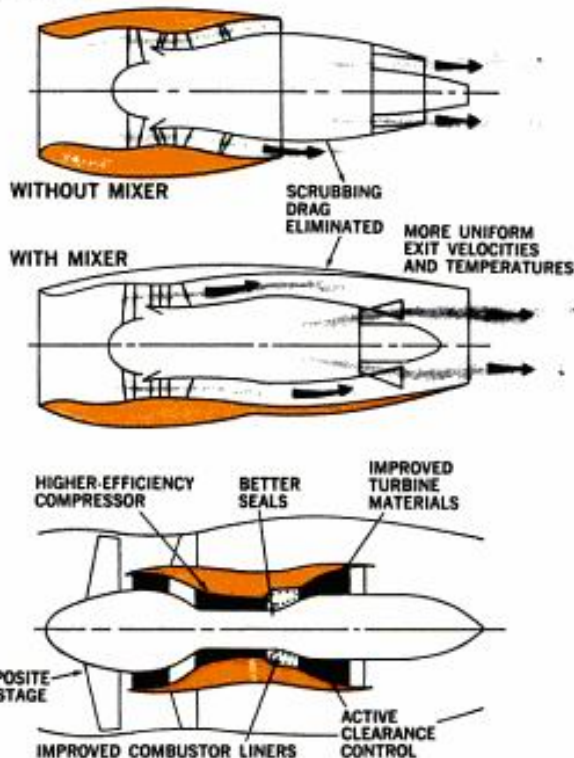
Turboprop passenger transports (in model form below), may reappear in fuel-efficient designs like this. A recent Lockheed study found that such prop-fan planes would use 18 percent less fuel than turbofan aircraft at the same cruising speed.



Aerodynamic and engine technology for fuel efficiency



Drag reduction with laminar flow control (LFC) on wings and other surfaces (upper left) could achieve 20- to 40-percent fuel savings. Suction in wing minimizes turbulent air near surfaces. Flat-topped supercritical wing (above, left) can be built thicker than conventional wing—without increasing drag. Thicker wings permit longer spans that improve aerodynamic efficiency. Mixer technology for jet



engines (upper right), tested in models, indicates that blending core and duct streams can boost propulsive efficiency and save fuel. A variety of improvements will go into advanced turbofan engines (above, right). The goal is to increase engine temperatures and pressures for improved thermodynamic efficiency. The new fan-jet design might cut fuel consumption by 10 to 15 percent.

depending on how much of the craft's surface is laminar-controlled. Some drag reduction might also be achieved by injecting air into the fuselage's boundary layer through numerous larger slots facing aft. However, even with a \$100 million NASA investment during the next decade, don't expect LFC airliners before the 1990's.

Several other projects are underway to reduce aerodynamic drag and improve lift. At NASA's Langley Research Center, wind-tunnel tests have shown that slightly flexible surfaces (sheets of Mylar-coated compressed foam) can reduce air-friction drag by 20 percent. Such compliant surfaces yield to rapid pressure changes within the boundary layer.

Curiously, an aquatic mammal, the porpoise, may be the inspiration for some future aerodynamic designs. Porpoises have a flexible, duct-filled skin that enables them to race at high speeds through the water. Aircraft designers, familiar with this principle, may one day pattern fuselage surfaces after the porpoise's resilient skin. However, a tough, durable material for aircraft must be developed first.

Another aerodynamical improvement called winglets might be added to some existing aircraft. Winglets are short vertical surfaces mounted on wing tips and slanted slightly outward. The vertical surfaces interact with air flow from the wings, producing a net forward thrust. NASA estimates winglets might provide a five-percent fuel saving.

Fuel-saving wings

The supercritical wing, a radical innovation developed by Dr. Richard Whitcomb of NASA, has been used largely for military and experimental aircraft, although modifications of the original design have been adapted for limited commercial use [PS, April '75]. The wing's flattened top reduces the drag produced by the shock waves that develop as a plane approaches supersonic speeds, and enables the plane to go faster without sharply increased drag.

The supercritical wing could conserve fuel, too. The novel wing can be made up to 50 percent thicker than conventional wings without a loss of efficiency. Thicker wings permit the wing span to be in-

creased for greater aerodynamic efficiency. Combining winglets and supercritical wings could save 10 to 15 percent in fuel over that of current wide-body jets, NASA estimates. It may be possible to retrofit some current aircraft with these advanced wings in the early 1980's.

Active controls

Using motion sensors, on-board computers, and electrohydraulic devices to achieve active controls is yet another way to reduce fuel-robbing aerodynamic drag and buffeting.

Traditionally, airplanes have been designed to have "inherent static stability." This means a plane won't fly violently off course when a pilot removes his hands and feet from the controls. This stability, however, dictates an aircraft's tail size and some fuselage parts. The military, requiring superior speeds, range, and/or payloads, began compromising static stability for performance more than 20 years ago. The B-58 supersonic bomber, for instance, can be piloted at certain speeds and loads only with the aid of a sophisticated computer.

Commercial airline operators have

been understandably reluctant to reduce static stability. But as their airliners have grown in size and weight, they have accepted boosted controls (the equivalent of power steering in your car), and a duplication of systems for maximum reliability.

A switch to active controls will put most movement of aircraft control surfaces in the hands of computers. As a result, several design changes will be possible: Smaller horizontal tails (less drag) and larger wing surfaces can be used. With the computer precisely distributing aircraft loads during maneuvers, less structural strength and weight will be necessary; this could result in a five-percent fuel saving.

Flying fibers

Composite materials, which are usually blends of boron or graphite fibers in a resin or aluminum matrix, may eventually trim aircraft weights by 25 percent, providing a 10- to 15-percent fuel saving. Used in aircraft for years, composites are lighter, stronger, and apparently longer-lasting than the metal parts they replace. So far, however, these super-tough materials have been used only for non-critical parts, such as rudders, panels, and spoilers—a fraction of total aircraft weight.

The aircraft industry moves cautiously about introducing these highly promising materials for primary-wing, fuselage, and tail structures. As yet, there is not enough data available on such critical questions as fatigue lifetime, maintenance, or exposure to weather and lightning strikes.

Better engines

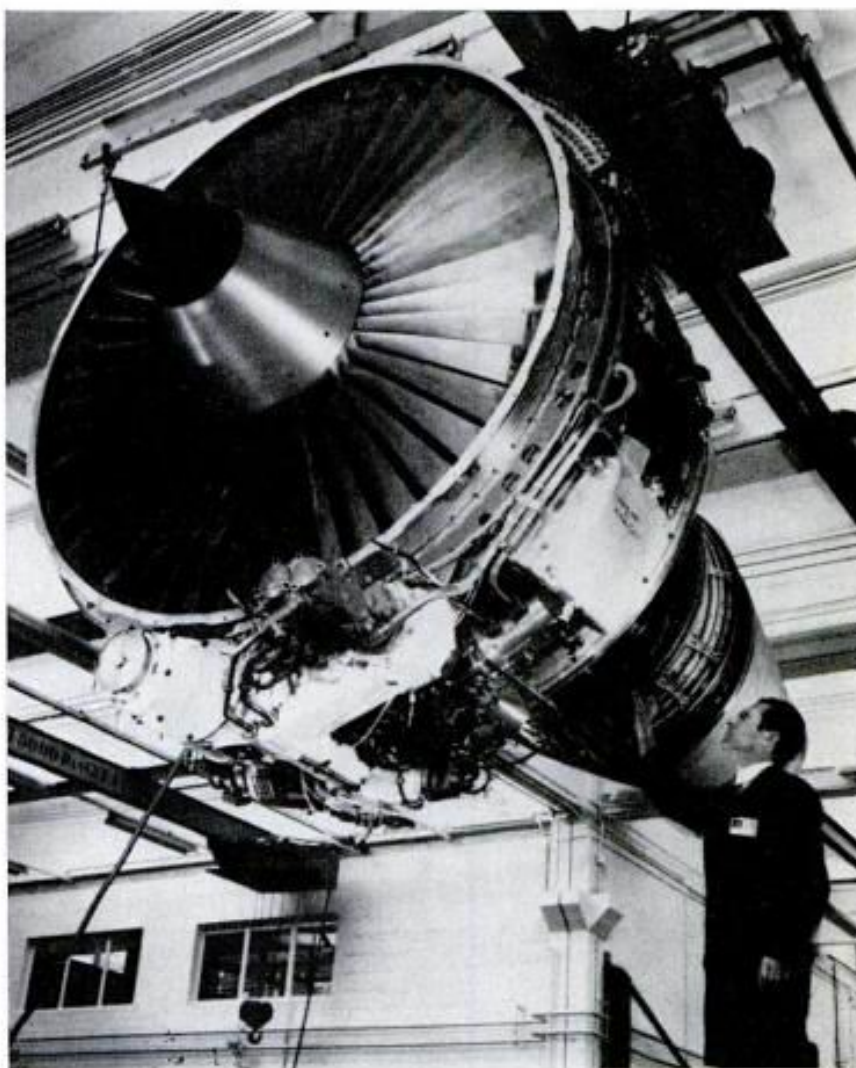
A wide spectrum of activities have been proposed to improve existing jet engines. Despite periodic maintenance, the performance and fuel efficiency of today's engines gradually deteriorate. The causes are well known: Compressors and turbine tips wear, ducts develop leaks, turbine blades erode, bearing seals wear, and fans pick up nicks. NASA has endorsed a plan to monitor engines now in service to determine how such wear can be minimized.

Other refinements, such as reducing the gaps between spinning and stationary parts, can aid fuel efficiency. Engineers are looking at sensor-monitored clearance controls to prevent catastrophic rubbing of engine components.

Enclosing engines in mechanical

[Continued on page 161]

Fuel-saving engines and planes that are already here



High-bypass-turbofan engine (top), under joint development by General Electric and France's SNECMA, uses 15 to 20 percent less fuel than low-bypass engines now powering short/medium-haul aircraft. The CFM56 turbofan (fan-jet) is in the 22,000-lb. (10-ton) thrust class. Pratt & Whitney's new JT10D is similar to the CFM56, but neither is yet in commercial use.

Boeing's new 747SP (above) has begun flights using 10 to 12 percent less fuel than its sister transport, the basic 747. The 747SP, the only transport capable of nonstop service between New York and Tokyo (6754 miles), is 47 ft. shorter and weighs from 38 to 58 tons less than the 747. The reduced weight, and a higher cruise altitude, means less work for the engines.